

**MITSUBISHI
MARINE ENGINE**

Engine. No.: 010495
010496

S6M3H-T2MTKL

for Propulsion

OPERATION & MAINTENANCE MANUAL

Issued: March 2025

Pub. No. 298T1-40120

Revision:1

CAUTION

- Read this Operation & Maintenance Manual, and conduct the engine operation, inspection and maintenance only after sufficiently understanding the description.
- Please keep this Operation & Maintenance Manual with related manuals at a suitable place for quick reference when needed.



**MITSUBISHI HEAVY INDUSTRIES
ENGINE & TURBOCHARGER**

♦Company names or product names described in this Operation & Maintenance Manual are trademarks or registered trademarks of their respective owners in general.

FOREWORD

This Operation & Maintenance Manual describes information and basic points required to use the Mitsubishi Diesel Engine (hereinafter called the "engine") correctly and effectively.

Please read this manual before using the engine.

In addition, operation, inspection and maintenance of the engine must be limited to the persons who understand the contents of this manual sufficiently.

Failure to follow instructions in this manual may result in serious accidents and increase in emission gas.

■ California, U.S.A.- Proposition 65 warning statement



WARNING: Breathing diesel engine exhaust exposes you to chemicals known to the State of California to cause cancer and birth defects or other reproductive harm.

- Always start and operate the engine in a well-ventilated area.
- If in an enclosed area, vent the exhaust to the outside.
- Do not modify or tamper with the exhaust system.
- Do not idle the engine except as necessary.

For more information go to www.P65warnings.ca.gov/diesel.

Important Information

Important Tips for Safety of Work

- ♦To avoid a potential risk, you must thoroughly understand the functions of this engine.
- ♦All involved personnel should actively participate, recognize their roles, and organize themselves and their work to ensure a safe environment.
- ♦To prevent injury, fatal accident or damage to this engine, you must obey the cautions, compliance rules and normal directions of use described in this manual while giving the highest priority to safety. If you do not obey them,
 - ♦it could result in death in the worst case.
 - ♦it could threaten your health.
 - ♦it may cause damage to this engine or the devices.
- ♦Since there are many actions that cannot be performed or must not be performed, it is impossible to indicate every caution in this manual or on warning labels.

As such, it is extremely important to follow instructions in this manual and also to take general safety measures when operating, inspecting, and maintaining the engine.

- ♦Descriptions about devices and facilities outside the scope of our supply are included in this manual. For the devices and facilities outside the scope of our supply, refer to the corresponding manual of the generator and the supplier's operation manual and obey the descriptions.
- ♦Electrical instruments must be inspected or maintained by a person who has received education and training for handling and avoiding risks about the electrical instruments on the machine, in addition to general knowledge needed for electric construction work.

General

- ♦This engine must be operated, inspected and maintained only by qualified persons who have thorough knowledge of engines and their dangers, and also have received risk avoidance training.
- ♦Be sure to read and understand this manual before operating, inspecting, and maintaining the engine. Working with insufficient understanding could cause personal injury or damage to the devices due to unexpected operation of them.
- ♦Inadequate operation or maintenance will cause unexpected damage to the device due to accumulated engine damage if not cause immediate failure. Carefully perform engine operation and maintenance.
- ♦Be sure to obey the applicable laws and regulations of the national government and other local municipalities.
- ♦When disposing this engine, follow the method defined by the national government or other local municipalities.
- ♦When discarding fuel, engine oil, or coolant, follow the method defined by the national government or other local municipalities.
- ♦The devices covered by the recycle law and those for which recycling requirements are stipulated shall be disposed in accordance with the corresponding laws and regulations.
- ♦Install an hour meter on the engine so that you can find the exact engine operating time, thereby performing the specified maintenance at the appropriate time in accordance the Scheduled Maintenance as described herein.
- ♦When modifying this engine, changing the specifications, and disassembling it, contact your Mitsubishi dealer. If the customer modifies the engine or changes the specifications, it could become impossible to ensure safety.

- ♦Mitsubishi Heavy Industries Engine & Turbocharger, Ltd. (MHIET) cannot foresee all potential dangers of the engine, potential dangers resulting from human error and other causes, or a danger caused by a specific environment in which the engine is used.
- ♦For the devices and facilities outside the scope of our supply, provide the corresponding manuals as "Usage Information" to the operators and let them obey the descriptions. MHIET will not bear a responsibility for damage or injury caused by the devices and facilities outside the scope of our supply.
- ♦In some countries or regions, this engine cannot be used depending on the laws, regulations and installation environment. When transferring this engine to a third party, check the regional conditions of them and contact your Mitsubishi dealer.
- ♦Make sure that all warning/caution/emission labels are legible. Clean or replace the labels when the description and/or illustration are not clear to read.
 - ♦Illegible labels fail to alert people, which may cause personal injury, environmental pollution, and damage to the engine.
- ♦For cleaning the labels, use a cloth and soapy water. DO NOT USE CLEANING SOLVENTS, GASOLINE, OR OTHER CHEMICALS THAT MAY ERASE THE PRINT OR CAUSE PEELING OFF OF THE LABEL. If the labels are damaged, replace them with new ones.
- ♦When replacing a part that has a label attached, attach the new label to the new part so that it is in the same state as before replacement.
- ♦New labels are available at your MHIET dealer, MHIET group company, or MHIET.

Important Tips for Managing Safety of Work

- ♦You must prepare a "Safety Manual", which describes your management criteria and operation rules. The supervisor must have the operators understand the "Safety Manual" preliminarily. In addition, keep the manual at hand so the operator can read it whenever necessary.
- ♦In order to prevent a disaster, the accident prevention measures must be suitable for the functions and specifications of this engine.
- ♦The accident prevention activities must be as the occupational safety and health management system planned and performed organizationally and continuously. This occupational safety and health management system must include the following points:
 - ♦Proper location of this engine
 - ♦Instructions concerning maintenance and usage of the operators' personal protective equipment
 - ♦Organization of the operation management system such as preparation of operation standards, clarification of the operation command system, etc.
 - ♦Education and training of the operators
- ♦Important purposes of the safety measures are to prevent personal injuries, protect the environment, and protect the engine. Always consider environmental protection.
- ♦Mitsubishi Heavy Industries Engine & Turbocharger, Ltd. (MHIET) shall accept no responsibility for loss or injury resulting from not observing instructions in this manual, or not paying attention to commonly required precautions when operating, inspecting or maintaining this engine.

About This Manual

- ♦This manual is intended for native speakers of the language in which the manual is written. If the operator of this engine is not a native speaker of the language used in this manual, the owner of the engine is requested to provide thorough safety guidance to the operator. Also prepare and affix warning labels written in the native language of the operators.
- ♦MHIET possesses the copyright of this manual. All rights reserved. No part of this manual, including illustrations and technical descriptions, may be photocopied, translated, or reproduced, in whole or in part, in any electronic medium or machine readable form without prior written consent from MHIET.
- ♦Illustrations in this manual may differ from the engine you have purchased. Covers can be omitted from illustrations to provide a better view of the inside.
- ♦The contents of this manual are subject to change without any notice.
- ♦When transferring this engine to a third party, make sure to attach this manual.
- ♦Keep this manual in the usual place so that it can be used any time.
- ♦If you need more information or if you have any questions, contact your MHIET dealer.

Warranty Provisions

1. Mitsubishi Heavy Industries Engine & Turbocharger, Ltd. (hereinafter referred to as MHIET) shall make a repair or replacement of a failure or damage at no charge, only when the said failure or damage occurs during the warranty period (refer to the individual contract) of this engine, and MHIET admits that its cause arises from the material, a problem of production, or a problem concerning our construction work within the scope of the contract specifications. The above-mentioned warranty period of this engine is not updated or prolonged by the said repair.
2. The above-mentioned warranty is the only one provided by MHIET concerning this engine.
No new contracts or warranties arise from this manual.
MHIET will not bear a responsibility for any loss (including, but not limited to direct loss, indirect loss, lost profits, operating losses, down time loss, etc.) caused by any reason, regardless of whether the warranty period is expired or not.
3. The warranty coverage is effective for the original purchaser only. Those to whom ownership is later transferred are not provided with the warranty.
4. We may deny the warranty coverage regardless of the warranty period if fault or damage has been caused to the engine by any reason mentioned below:
 - ♦ Fault or damage caused by operation or maintenance deviated from the instructions or cautions described in this manual
 - ♦ Fault or damage caused by being repaired or modified by other than us/Mitsubishi dealer, or by illegal act
 - ♦ Fault or damage caused by abuse, misuse, incorrect operation or misapplication
 - ♦ Fault or damage caused by operation or maintenance beyond the specification limit
 - ♦ Fault or damage caused by use of spare parts, optional parts or consumables (including engine oil, LLC and fuel) that MHIET do not recommend
 - ♦ Fault or damage caused by a natural disaster (earthquake, typhoon, flood, seismic sea waves, volcanic eruption, etc.) fire, war, terrorism, or other abnormal operational conditions which MHIET cannot bear responsibility
 - ♦ Fault or damage caused by the location of this engine (for example, electromagnetic environment stress)
 - ♦ Fault or damage caused by resale or relocation
 - ♦ Fault or damage caused by consumption or age deterioration
 - ♦ Fault or damage caused by other reasons which MHIET cannot bear responsibility

Warning Indication

The following signs and symbols are used to call attention of the operators and maintenance personnel to potential dangers of the engine.

- ♦Warning Statements in This Manual
- ♦Warning Labels Attached on the Engine

Warning Statements

The warning statements in this manual describe potential danger in operation, inspection, and maintenance of the engine, using the five symbols below to indicate the degree of potential hazard.

Failure to follow these directions could lead to serious accidents which could result in personal injury, or death in the worst case.

Please understand the instructions described in this manual well, and handle the engine according to the instructions.



Indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.



Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.



Indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury.



Indicates a potentially hazardous situation which, if not avoided, may result in property damage.

Note:

Indicates important or useful information related to the operation and maintenance of the engine.

Unit of Measurement

Measurements are based on the International System of Units (SI), and they are converted to the metric system units shown in { } in this manual. Conversion rates are as follows:

- ♦Pressure: 1 MPa = 10.197 kgf/cm²
- ♦Torque: 1 N•m = 0.10197 kgf•m
- ♦Force: 1 N = 0.10197 kgf
- ♦Power, output: 1 kW = 1.341 HP = 1.3596 PS
- ♦Rotational speed: 1 min⁻¹ = 1 rpm
- ♦Kinetic viscosity: 1 mm²/s = 1 cSt

Abbreviations, Standards and Others

- ♦API = American Petroleum Institute
- ♦ASTM = ASTM International
- ♦CARB = California Air Resources Board
- ♦CCS = Cold Cranking Simulator
- ♦EPA = United States Environmental Protection Agency
- ♦FED = Federal Specifications and Standards
- ♦ISO = International Organization for Standardization
- ♦JIS = Japanese Industrial Standards
- ♦JPI = Japan Petroleum Institute
- ♦LLC = Long Life Coolant
- ♦MHIET = Mitsubishi Heavy Industries Engine & Turbocharger, Ltd.
- ♦MRV = Mini - Rotary Viscometer
- ♦OSHA = Occupational Safety and Health Administration
- ♦SAE = Society of Automotive Engineers
- ♦SDS = Safety Data Sheet

Regulation for the Prevention of Air Pollution From Ships

Engine International Air Pollution Prevention Certificate and Technical File

The engine you have purchased is provided with "Engine International Air Pollution Certificate" (EIAPP-certificate) which proves the NOx regulation compliance of MARPOL 73/78 Annex VI, regulation for the Prevention of Air Pollution from Ships, and "Technical File." The ship which is built after 1 January 2000 must be equipped with the marine use engine that complies with the NOx regulations. EIAPP-certificate and Technical File must be kept on board all the time. If you fail to do so, you may receive penalties for violations.

Owner's Responsibilities Confirming the Engine Maintenance Description (With Signature)

NOx regulation approval engine conditions such as part names and adjustment values are described in the Technical File. When you repair the engine or do maintenance work (part replacement, adjustment), you must follow the instructions described in the Technical File and perform the repair or maintenance work properly. Ship-owner, captain, and chief engineers have a responsibility to verify the work that has been done, and record every detail of work on "Maintenance Records for Parameters" in the Technical File with signatures.

Chapter 1

SAFETY CAUTIONS

Fire and Explosion Protection.....	1-1
Keep Flames Away	1-1
Keep Engine Surrounding Area Tidy and Clean.....	1-1
Pay Attention to Engine Room Ventilation	1-1
Do Not Open Side Covers Until Engine Cools	1-1
Be Alert for Leaking Fuel, Oil, or Exhaust Gas	1-1
Use Explosion-Proof Light.....	1-1
Prevention of Electric Short Circuit	1-1
Keep Fire Extinguishers and First-Aid Kit Handy.....	1-1
Stay Away From Rotating and Moving Parts	1-2
Keep Rotating Parts Covered for Safety	1-2
Check Work Area for Safety Before Starting....	1-2
Stay Away From Moving Parts During Operation	1-2
Lockout and Tagout	1-2
Be Sure to Stop Engine Before Inspection/Maintenance	1-2
Always Put Turning Tool Back in Place After Use.....	1-2
Prevention of Exhaust Gas Poisoning	1-3
Pay Attention to Ventilation When Operating Engine	1-3
Prevention of Hearing Loss	1-3
Wear Ear Plugs	1-3
Fall Prevention.....	1-3
Lift Engine Carefully	1-3
Do Not Climb Onto the Engine.....	1-3
Always Use a Stable Foothold During Maintenance.....	1-3
Burn Protection.....	1-4
Do Not Touch Engine During or Immediately After Operation	1-4
Be Careful When Opening and Closing of Fresh Water Tank Pressure Cap.....	1-4
Refill Coolant Only After the Coolant Temperature Dropped	1-4
Do Not Remove Heat Shields	1-4
Burn Prevention When Changing Oil	1-4
Be Careful When Handling Fuel, Engine Oil, and Coolant (LLC).....	1-4
Use Specified Fuel, Engine Oil, and LLC Only	1-4
Handle LLC Carefully	1-4
Proper Disposal of Waste Oil, LLC, and Coolant.....	1-4
When a Problem Occurs	1-5
Stop Operation Immediately If You Notice Any Ab-	

normality	1-5
Do Not Add Coolant Immediately After a Sudden Stop Due to Overheating.....	1-5
Be Careful When Starting After an Abnormal Stop	1-5
Stop Engine Immediately When Engine Oil Pressure Has Dropped.....	1-5
If Belt Breaks, Stop Engine Immediately	1-5
Battery Safety Precautions	1-5
Be Careful When Handling Battery	1-5
Other Precautions	1-6
Do Not Tamper.....	1-6
Always Use Mitsubishi Genuine Parts.....	1-6
Observe Safety Rules at Work Site.....	1-6
Wear Proper Work Clothing and Protective Gears	1-6
Never Break the Seals	1-6
Performance of Pre-operation Inspection and Periodic Inspections	1-6
Engine Break-in.....	1-6
Warming Up Engine First	1-7
Cool Down the Engine Before Stopping.....	1-7
Do Not Operate the Engine in an Overloaded Condition	1-7
Limitation of Continuous Under Light Load Operation	1-7
Do Not Splash Water on Engine	1-7
Pre-cleaner Maintenance Precautions	1-7
Use Proper Tools for Maintenance Work	1-8
Do Not Operate Starter for a Long Duration	1-8
Do Not Turn Off the Battery Switch During Operation	1-8
Engine Transportation Precautions	1-8
Do Not Turn Engine to Reverse Direction	1-8
Operate Clutch at Low Idling Speed	1-8
Shift Clutch Properly	1-8
Warning/Caution Labels.....	1-9
Maintenance of Warning/Caution Labels	1-9

Chapter 2

NAMES OF PARTS

Engine External Views	2-1
Front View	2-1
Rear View	2-1
Left View	2-2
Right View	2-2
Operating Devices	2-3
Speed Control Lever	2-3

Direction Lever	2-3
Stop Button	2-3
Manual Stop Lever	2-4
Transmitters for Instruments	2-5
Engine Protection Devices	2-6
Thermo Switch	2-6
Oil Filter Alarm Switch.....	2-6
Instrument Panel	2-7

Chapter 3 OPERATION

Preparation for Operation of New or Overhauled Engine	3-1
Preparation of Fuel System.....	3-1
Preparation of Lubrication System	3-3
Preparation of Cooling System	3-4
Preparation of Electrical System	3-5
Test Operation	3-6
Preparation of Operation for Overhauled Engines	3-7
Normal Engine Operation	3-9
Pre-operation Inspection	3-9
Engine Exterior - Inspection	3-9
Fuel Tank Oil Level - Check.....	3-10
Engine Oil Level - Check.....	3-10
Coolant Level - Check.....	3-11
Warning Indicator Light - Operation Check....	3-12
Control Cable - Check.....	3-12
Control Lever - Operation Check	3-12
Start-up.....	3-13
Cautions When Starting	3-13
Starting Procedures	3-13
Warm-up Operation	3-15
Engine Oil Pressure - Check.....	3-15
Engine - Walk Around Check	3-15
Marine Gear Oil Level - Check.....	3-15
Operation.....	3-16
Precautions in Engine Operation	3-16
Stopping	3-18
Cautions When Stopping	3-18
Stopping Procedure	3-18
Trolling Operation	3-20
Conditions of Use for Trolling Operation	3-20
Trolling Operations.....	3-20
When Trolling Device is Not Used	3-20

Chapter 4 FUEL

Recommended Fuel.....	4-1
Handling Fuel.....	4-1
Fuel Quality Standard	4-2

Chapter 5 ENGINE OIL

Use Recommended Engine Oil Only ..	5-1
Genuine MHIET Engine Oil.....	5-1
Other Commercial Engine Oils	5-1
Handling Engine Oil	5-5
Marine Gear Oil.....	5-5
Service Limits for Engine Oil	5-6
Definition of Property Limit of Engine Oil.....	5-7
Kinetic Viscosity	5-7
Base Number	5-7
Acid Number	5-7
Water Content	5-7
Flash Point	5-7
Insolubles	5-7
Engine Oil Analysis Service	5-8

Chapter 6 COOLANT

Recommended Water for Coolant	6-1
Long Life Coolant (LLC).....	6-1
Genuine MHIET LLC.....	6-1
Other Commercial LLCs	6-2
Requirements for Other Commercial LLCs.....	6-2
General Quality Requirements for LLC	6-2
LLC Quality Standard.....	6-3
Maintenance of LLC.....	6-6
Replacement Intervals of LLC.....	6-6
LLC Concentration (GLASSY and PG GLASSY).....	6-6
LLC Concentration Measuring Method	6-7
Necessity of LLC.....	6-10
Characteristics of LLC Additives	6-10
Examples of Abnormalities Caused by Amine Type LLC	6-10
Pitting of Iron Parts.....	6-10
Corrosion of Aluminum Parts	6-10

Pitting and Clogging of Heat Exchanger	6-10
--	------

Chapter 7

PERIODIC MAINTENANCE SCHEDULE

How to Use the Periodic Maintenance Schedule.....	7-1
Periodic Maintenance Schedule	7-3

Chapter 8

PERIODIC INSPECTION AND MAINTENANCE PROCEDURES

Engine	8-1
Engine Exterior - Inspect.....	8-1
Belt and Belt Tension - Inspect and Adjust	8-2
Damper - Inspect.....	8-3
Cold Weather Operations.....	8-4
Fuel System.....	8-5
Fuel System - Inspect	8-5
Fuel Tank - Clean.....	8-5
Fuel Tank - Drain Water.....	8-5
Gauze Filter - Clean	8-6
Fuel Filter - Replace.....	8-7
Fuel Pipe - Inspect	8-8
Lubrication System	8-9
Engine Oil, Oil Filter, and Bypass Oil Filter - Replace	8-9
Ingress of Fuel and Water In Engine Oil - Inspect	8-12
Marine Gear Oil - Change, Marine Gear Oil Strainer - Clean, Marine Gear Cover Oil Filter - Replace	8-13
Cooling System	8-15
Coolant - Change	8-15
Fresh Water Pump - Lubricate	8-17
Sea Water - Drain	8-18
Sea Water Pump Impeller - Inspect	8-19
Zinc Rod - Inspect.....	8-19
Inlet and Exhaust Systems	8-20
Turbocharger - Inspect.....	8-20
Pre-cleaner - Clean, Inspect, and Replace	8-21
Electrical System	8-22
Starter - Inspect.....	8-24
Alternator - Inspect.....	8-24

Chapter 9

LONG-TERM STORAGE

Storing Engine in an Inoperable Condition for 3 Months up to 1 Year	9-1
Preparation for Storage	9-1
Maintenance During Storage	9-1
When Using Engine After Storage	9-2
Storing Engine in an Operable Condition	9-2
Operation for Maintenance Purpose	9-2

Chapter 10

TRANSPORTATION

Lifting Engine	10-1
----------------------	------

Chapter 11

TROUBLESHOOTING

General Precautions	11-1
Contact Your MHIET Dealer for Repair Service	11-1
Considerations Before Proceeding with Corrective Action	11-1
Cautions Against Contamination	11-1
Cautions for Parts Handling	11-1
Safety Working Practices	11-1
Troubleshooting	11-2
Tends To Overheat	11-2
When Engine Oil Pressure is Abnormal	11-2
When Marine Gear Oil Pressure is Abnormal	11-3
While Being Towed or During Towing	11-3
Problems, Probable Causes, and Solutions	11-4
The Starter Does not Crank or Cranks Slowly, Resulting in Start Failure	11-4
Starter Cranks, but Engine Does Not Start	11-5
Insufficient Output	11-6
Exhaust Smoke is White or Blue	11-7
Exhaust Smoke is Black or Gray.....	11-8
Excessive Fuel Consumption	11-9
Excessive Engine Oil Consumption	11-10
Overheating.....	11-10
Engine Oil Pressure Drop	11-11
When Fuel has Run Out	11-12

Chapter 12

MAIN SPECIFICATION

Main Specifications.....12-1

REVISION HISTORY

List of Illustrations

Fig. 1-1Common Warning/Caution Labels	1-10
Fig. 2-1Engine Front View	2-1
Fig. 2-2Engine Rear View	2-1
Fig. 2-3Engine Left-Side View	2-2
Fig. 2-4Engine Right-Side View	2-2
Fig. 2-5Speed Control Lever.....	2-3
Fig. 2-6Direction Lever.....	2-3
Fig. 2-7Stop Button.....	2-3
Fig. 2-8Manual Stop Lever	2-4
Fig. 2-9Oil Pressure Unit.....	2-5
Fig. 2-10Thermo Unit	2-5
Fig. 2-11Rotation Detection Pickup	2-5
Fig. 2-12Thermo Switch.....	2-6
Fig. 2-13Oil Filter Differential Pressure Alarm Switch.....	2-6
Fig. 2-14Instrument Panel	2-7
Fig. 3-1Priming Pump Cap - Handling.....	3-1
Fig. 3-2Fuel Filter - Bleed Air	3-2
Fig. 3-3Fuel Injection Pump - Bleed Air.....	3-2
Fig. 3-4Oil Filler and Oil Level Gauge	3-3
Fig. 3-5Fresh Water Tank Pressure Cap	3-4
Fig. 3-6Coolant Drain Cock (Engine Body).....	3-4
Fig. 3-7Reserve Tank Coolant Level.....	3-4
Fig. 3-8Battery Fluid Level - Check	3-5
Fig. 3-9Valve Open/Closed Position - Check.....	3-9
Fig. 3-10Oil Filler and Oil Level Gauge	3-10
Fig. 3-11Fresh Water Tank Pressure Cap	3-11
Fig. 3-12Reserve Tank Coolant Level.....	3-11
Fig. 3-13Warning Indicator Light - Operation Check.....	3-12
Fig. 3-14Control Lever - Operation Check	3-12
Fig. 3-15Battery Switch "ON"	3-13
Fig. 3-16Control Lever Start Position.....	3-14
Fig. 3-17Starter Switch "HEAT"	3-14
Fig. 3-18Starter Switch "START"	3-14
Fig. 3-19Starter Switch "ON".....	3-14
Fig. 3-20Lubricating Oil Pressure Gauge	3-15
Fig. 3-21Marine Gear Oil Filler Cap and Oil Level Gauge.....	3-15
Fig. 3-22Control Lever Stop Position.....	3-18
Fig. 3-23Stop Button.....	3-18
Fig. 3-24Starter Switch "OFF".....	3-19
Fig. 3-25Battery Switch "OFF"	3-19
Fig. 3-26Trolling Valve Lever	3-20

Fig. 4-1Recommended Fuel	4-1	Fig. 8-24Sea Water Drain Cock (Heat Exchanger)	8-18
Fig. 4-2Recommended Fuel According to Ambient Temperature	4-1	Fig. 8-25Sea Water Pump Cover	8-18
Fig. 5-1MITSUBISHI DIESEL ENGINE OIL	5-1	Fig. 8-26Sea Water Drain Plug (Intercooler)	8-18
Fig. 5-2Engine Oil Grade	5-1	Fig. 8-27Sea Water Drain Plug (Marine Gear Oil Cooler)	8-18
Fig. 5-3Selection of Oil Viscosity	5-4	Fig. 8-28Sea Water Pump Impeller - Inspect	8-19
Fig. 6-1GLASSY Long Life Coolant	6-1	Fig. 8-29Zinc Rod - Judge	8-19
Fig. 6-2Coolant Freezing Temperature (GLASSY and PG GLASSY)	6-6	Fig. 8-30Zinc Rod Mounting Location (Marine Gear Oil Cooler)	8-19
Fig. 6-3Coolant Tester	6-7	Fig. 8-31Turbocharger - Inspect	8-20
Fig. 6-4Measuring Procedure 1	6-7	Fig. 8-32Pre-cleaner - Wash	8-21
Fig. 6-5Measuring Procedure 2	6-7	Fig. 8-33Battery Fluid Level - Check	8-22
Fig. 6-6Measuring Procedure 3	6-7	Fig. 8-34Specific Gravity of Battery Electrolyte - Check	8-23
Fig. 6-7Measuring Procedure 4	6-8	Fig. 8-35Starter - Inspect	8-24
Fig. 6-8Measuring Procedure 5	6-8	Fig. 8-36Alternator - Inspect	8-24
Fig. 6-9Measuring Procedure 6	6-8		
Fig. 6-10Measuring Procedure 7	6-9		
Fig. 6-11Measuring Procedure 8	6-9		
Fig. 8-1Valve Open/Closed Position - Check	8-1		
Fig. 8-2Belt Tension (Alternator Side) - Adjust ...	8-2		
Fig. 8-3Belt Tension (Sea Water Pump Side) - Adjust	8-2		
Fig. 8-4Damper - Check Visually	8-3		
Fig. 8-5Fuel Tank - Drain Water	8-5		
Fig. 8-6Gauze Filter - Clean	8-6		
Fig. 8-7Fuel Filter - Replace	8-7		
Fig. 8-8Fuel Filter	8-7		
Fig. 8-9High-pressure Fuel Injection Pipe and Clamp Seat - Inspect and Replace	8-8		
Fig. 8-10Low-pressure Fuel Pipe, Oil Pipe, and Clip - Inspect and Replace	8-8		
Fig. 8-11Engine Oil - Drain Port	8-9		
Fig. 8-12Oil Filter - Change	8-10		
Fig. 8-13Bypass Oil Filter - Change	8-10		
Fig. 8-14Oil Filler and Oil Level Gauge	8-11		
Fig. 8-15Marine Gear Oil - Drain	8-13		
Fig. 8-16Marine Gear Oil Strainer - Clean	8-13		
Fig. 8-17Replace Marine Gear Governor Oil Filter	8-13		
Fig. 8-18Marine Gear Oil Filler Cap and Marine Gear Oil Level Gauge	8-14		
Fig. 8-19Fresh Water Tank Pressure Cap	8-15		
Fig. 8-20Coolant Drain Cock (Engine Body)	8-15		
Fig. 8-21Coolant Drain Cock (Engine Body)	8-16		
Fig. 8-22Reserve Tank Coolant Level	8-16		
Fig. 8-23Fresh Water Pump - Lubricate	8-17		

List of tables

Table 2-1Instrument Panel	2-7
Table 3-1Break-In Operation	3-7
Table 3-2Pre-heating Time in Cold Climates (Air Heater)	3-13
Table 3-3Rotation Speed Control Range (Marine Gear MGN123GX)	3-20
Table 4-1Recommended Limit and Service Limit for Fuel Properties	4-2
Table 5-1Engine Oil Quality Standards (Grade CF SAE 30)	5-2
Table 5-2Engine Oil Quality Standards (Grade CF SAE 15W-40)	5-3
Table 5-3Engine Oil Quality Standards (Grade CH-4 SAE 15W-40)	5-4
Table 5-4Engine Oil Properties	5-6
Table 6-1Water Quality Standard	6-1
Table 6-2LLC Quality Standard	6-3
Table 6-3Recommended LLC Concentration	6-6
Table 7-1Rating Definition for Diesel Engine for Marine Propulsion Application	7-2
Table 7-2Periodic Maintenance Schedule	7-3
Table 8-1Specific Gravity of Battery Electrolyte ..	8-23
Table 9-1Table for Recommended Rust-Preventive Oil and Corrosion Inhibitor	9-1
Table 11-1When Engine Oil Pressure is Abnormal	11-2
Table 11-2When Marine Gear Oil Pressure is Abnormal	11-3
Table 11-3The Starter Does not Crank or Cranks Slowly, Resulting in Start Failure	11-4
Table 11-4Starter Cranks, but Engine Does Not Start	11-5
Table 11-5Insufficient Output	11-6
Table 11-6Exhaust Smoke is White or Blue	11-7
Table 11-7Exhaust Smoke is Black or Gray	11-8
Table 11-8Excessive Fuel Consumption	11-9
Table 11-9Excessive Engine Oil Consumption ..	11-10
Table 11-10Overheating	11-10
Table 11-11Engine Oil Pressure Drop	11-11
Table 12-1Main specifications	12-1

Chapter 1 SAFETY CAUTIONS

Fire and Explosion Protection



WARNING

Keep Flames Away

Do not use flames near the engine (in the engine room). Fuel gas vapor or other gas may catch fire and produces hazardous situations.



Wipe off spilled fuel, engine oil, and LLC immediately and thoroughly. Spilled fuel, engine oil, and LLC may ignite and cause a fire. Store the fuel and engine oil in a well-ventilated area. Make sure that the caps of fuel and engine oil containers are tightly closed.

Keep Engine Surrounding Area Tidy and Clean

Do not leave combustible or explosive materials such as fuel, engine oil, and LLC near the engine. It may cause a fire or explosion.

Remove dust, dirt, and other foreign substances accumulated on the engine and surrounding area. Such materials may cause a fire or overheating. In particular, clean the top surface of the battery after maintenance work is completed. Dust may cause a short-circuit.

Pay Attention to Engine Room Ventilation

Always keep the engine room well ventilated. Insufficient air in the room may cause an increase in the engine temperature and a decrease in the output power and performance. Prior to installation of the engine, it is recommended to provide an adequate ventilation system by calculating the proper amount of supply air needed for the engine.

Do Not Open Side Covers Until Engine Cools

Do not attempt to open the side cover of the crankcase before the engine cools down. Wait at least 10 minutes after stopping the engine.

If fresh air flows into the crankcase while the engine is overheating, oil mist may be ignited and exploded.

Be Alert for Leaking Fuel, Oil, or Exhaust Gas

If any fuel, oil, or exhaust gas leak is found, immediately stop the engine. After the engine has completely cooled down, repair the leak.

If oil/fuel splashes or leaks on the hot surfaces of the engine, or if exhaust gas comes in contact with flammable materials, it may cause property damage or personal injury.

Use Explosion-Proof Light

When inspecting fuel, engine oil, cooling water, battery electrolyte, etc., use a flameproof light. An ordinary lighting apparatus may ignite gas and cause an explosion.

Prevention of Electric Short Circuit

Do not inspect or repair the electrical system with the ground cable connected to the battery. Otherwise, a fire could result from short-circuit. Be sure to disconnect the battery cable from the negative (-) terminal before proceeding with any work.

Short-circuit, which may result in fire, is caused by a loose terminal or damaged cable/wire. Inspect terminals, cables, and wires, and repair or replace faulty parts before proceeding with any work.

Keep Fire Extinguishers and First-Aid Kit Handy

Keep fire extinguishers handy and become familiar with the usage. Keep a first-aid kit at the designated place where it is easily accessible by anyone at any time.



Prepare an emergency action plan in the event of fire or accident. Provide an emergency evacuation route and contact points and means of communication in case of emergency.

Stay Away From Rotating and Moving Parts



WARNING

Keep Rotating Parts Covered for Safety

Make sure the protective covers attached to the engine rotating parts are correctly installed. Repair any damaged or loose covers. During operation, never remove protective covers such as the front cover, fuel injection pump coupling cover, and alternator cover that enclose rotating parts.



When the engine is coupled to the driven equipment, be sure to provide protective covers over the parts such as the connecting belts and couplings that are exposed.

Never remove the protective covers.

Check Work Area for Safety Before Starting

Before starting the engine, make sure no one is near the engine and no tools are left on or near the engine. Alert people in the area when starting the engine.

When the starter device is posted with a sign that prohibits startup operation, do not operate the engine.

Stay Away From Moving Parts During Operation

Stay away from rotating parts of the engine while the engine is running. Do not place any objects which might be easily entangled near the rotating parts.



If any part of the clothing or tool is caught in rotating parts, it may result in serious injury or death.

Lockout and Tagout

Be sure to lockout/tagout before starting inspection and maintenance work.

Lockout and tagout are effective methods of cutting off machines and equipment from energy sources.

To accomplish the lockout/tagout, remove the starter switch key, place the battery switch to the OFF position and attach a "DO NOT OPERATE" or similar caution sign to the starter switch.

The starter switch key must be kept by the person who performs inspection and maintenance work.

Be Sure to Stop Engine Before Inspection/Maintenance

Be sure to stop the engine before proceeding with any inspection and maintenance work. Never attempt to make any adjustments on the engine parts while the engine is running.

Entanglement in rotating parts may result in serious injury or death.

Always Put Turning Tool Back in Place After Use

Be sure to remove the turning tool used during inspection and maintenance after use. If the turning tool is left inserted or the engine is started in a turning state, the engine will not only break, but it may also lead to personal injury.

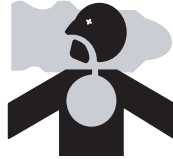
Prevention of Exhaust Gas Poisoning

WARNING

Pay Attention to Ventilation When Operating Engine

Check exhaust pipes and pipe joints for gas leaks.

Exhaust gas from the engine may contain harmful substances to human body. Operating the engine in a poorly-ventilated area could cause gas poisoning.



Prevention of Hearing Loss

CAUTION

Wear Ear Plugs

Always wear ear plugs when entering the machine room (engine room).

Combustion sound and mechanical noise generated by the engine may cause hearing problems.



Fall Prevention

WARNING

Lift Engine Carefully

To lift the engine, use slings strong enough to support the weight of the engine.

Attach proper slings to the hangers provided on the engine to lift the engine.

During the lifting process, keep the engine in a well-balanced position by paying attention to the center of gravity of the engine.

The hangers attached to the engine are designed to lift the engine only. When the engine is equipped with marine gear, take care so that extra load will not impose on the engine hangers.

Keep the angle formed by slings that are attached to hangers within 60 degrees. If the angle exceeds this limit, an excessive load could be imposed on the hangers and this could damage the hangers and result in a serious accident.

Attach wire ropes to the hangers after removing the pipe near the hanger.

If the sling contacts the engine parts directly, place a cloth or other soft padding to avoid damage to the engine parts and sling. If necessary, remove the engine parts.



Do Not Climb Onto the Engine

Do not climb onto the engine, nor step on any engine parts, which located on the engine sides.

When working in a high place such as the upper part of engine, use a step, or work platform, and be careful not to fall off.

Climbing on the engine may not only damage engine parts but also cause a falling-down accident which could result in a personal injury.

Always Use a Stable Foothold During Maintenance

When working on the upper part of the engine and other hard-to-reach places, use a stable work platform.

Do not stand on an unstable stool or parts box. Otherwise, it could result in personal injury.

Do not put any unnecessary objects on a work platform.



Burn Protection



CAUTION

Do Not Touch Engine During or Immediately After Operation

Do not touch any part of the engine during or immediately after operation. A hot engine may cause burns.

Before conducting maintenance and inspection work, check the water temperature gauge to see if the engine has cooled sufficiently.



Be Careful When Opening and Closing of Fresh Water Tank Pressure Cap

Never open the Fresh water tank pressure cap while the engine is running or immediately after stopping. Stop the engine, and then open the cap after the coolant temperature has dropped sufficiently.

To open the Fresh water tank pressure cap, open slowly to release the pressure in the tank.

The coolant is hot while the engine is running and immediately after stopping. If the Fresh water tank pressure cap is opened while the coolant is hot, steam and hot water may blow out and it may result in burns.

To avoid the risk of getting scalded by steam, wear thick rubber gloves or wrap a cloth around the cap.

When fastening the Fresh water tank pressure cap, be sure to tighten securely.

Refill Coolant Only After the Coolant Temperature Dropped

Before adding coolant, check the coolant temperature with the gauge if it is lowered to the normal temperature. Adding coolant immediately after engine shutdown may result in burns.

Do Not Remove Heat Shields

The inlet and exhaust systems are provided with various heat shields because they become extremely hot while the engine is running. Do not remove these heat shields. If any of these heat shields have been removed due to unavoidable circumstances for the work, be sure to install them after the work is completed.

Burn Prevention When Changing Oil

Before draining oil or changing oil filters, wear leather gloves or be sure to check the engine has cooled down. Hot oil or hot parts may cause burns if touched.

Be Careful When Handling Fuel, Engine Oil, and Coolant (LLC)



CAUTION

Use Specified Fuel, Engine Oil, and LLC Only

Use fuel, oil, and coolant (LLC) specified in this manual, and handle them carefully.

Use of any other fuel, oil, or coolant (LLC) than the specified one, or improper handling may cause various engine defects and failures.

Obtain the SDS issued by the oil and LLC suppliers, and follow the instructions in the SDS for proper handling.

Handle LLC Carefully

When handling LLC, always wear rubber gloves, a protective face mask, and protective eyeglasses. If LLC or cooling water containing LLC comes into contact with your skin or eyes, or if it is ingested, you may suffer from damage of your skin or eyes, or poisoning. If coolant (LLC) is accidentally swallowed, induce vomiting immediately, and seek medical attention. If coolant (LLC) gets in your eyes, flush them immediately with plenty of water and seek medical attention. If coolant (LLC) splashes onto your skin or clothing, wash it away immediately with plenty of water.

Keep flames away from LLC. LLC is highly flammable and can easily catch a fire if exposed to a flame.

Proper Disposal of Waste Oil, LLC, and Coolant

Do not dump waste engine oil, LLC, and coolant into sewerage, river, lake, or other similar places. Such a way of disposal is strictly prohibited by laws and regulations.

Be sure to dispose of waste oil, LLC, coolant, and other environmentally hazardous waste in accordance with the applicable laws and regulations.

When a Problem Occurs

CAUTION

Stop Operation Immediately If You Notice Any Abnormality

Stop the operation immediately if you notice any unusual noise, odor, or vibration during operation.

When an emergency occurs, press the emergency stop button to stop the engine. If the cause of problem cannot be located after stopping, contact your MHIET dealer. Continuous operation neglecting an unusual symptom could cause serious or fatal accident.

Do Not Add Coolant Immediately After a Sudden Stop Due to Overheating

If the engine stops suddenly or if you have no choice but stop the engine suddenly due to overheating, do not add coolant immediately.

Adding coolant while the engine is hot may cause damage to cylinder heads and others due to a sudden drop of temperature. Add coolant gradually after the engine has completely cooled.

Be Careful When Starting After an Abnormal Stop

Do not restart immediately after an abnormal stop. If the engine stops or is brought to a stopped condition with malfunction, find out the cause, repair the troubled part, and then restart the engine. Continued operation of the engine without proper repairs and maintenance may result in serious engine failure.

Stop Engine Immediately When Engine Oil Pressure Has Dropped

When excessive engine oil pressure drop is observed, stop the engine immediately, and inspect the lubrication system to locate the cause. Continued engine operation may cause bearings and other parts to seize.

If Belt Breaks, Stop Engine Immediately

If the belt breaks, stop the engine immediately and replace the belt. Continued use of the engine without any remedy may cause charging failure or cooling failure, and result in serious engine problems.

Battery Safety Precautions

CAUTION

Be Careful When Handling Battery

- Never use flames or allow sparks near the battery. The battery releases flammable hydrogen gas and oxygen gas. Any flames or sparks near the battery may cause an explosion.
- Do not use the battery when the battery fluid level is below the "LOWER LEVEL" mark. It may result in an explosion.
- Do not short the battery terminals with a tool or other metal object.
- When removing battery, always remove the plug from the negative (-) terminal first. When connecting battery, always connect the plug to the positive (+) terminal first.
- Before charging the battery, remove all battery cables, and then charge the battery in a well-ventilated area.
- Make sure the cable clamps are securely attached to the battery terminals. A loose cable clamp may cause sparks, which may result in an explosion.
- Before servicing electrical components or conducting electric welding, set the battery switch to the [OFF] position or remove the plug from the negative (-) terminal to cut off the electrical current.
- Battery fluid contains dilute sulfuric acid. Careless handling of the battery may lead to sight loss and/or skin burns. Also, do not swallow the battery fluid.
- Wear protective goggles and rubber gloves when working with the battery (e.g. when adding water or charging battery).
- If battery fluid is spilled onto the skin or clothing, immediately wash it away with lots of water. Use soap to clean thoroughly.
- The battery fluid may cause sight loss if splashing into your eyes. If it gets into your eyes, immediately flush it away with plenty of clean water, and seek immediate medical attention.
- If you accidentally swallow battery fluid, gargle with plenty of water and then drink lots of water, and seek immediate medical attention.
- If the battery does not fully recover after charging for 24 hours or more, do not use the battery.



Other Precautions


CAUTION

Do Not Tamper

Unauthorized modification of the engine will void your warranty.

Modification of the engine may not only cause damage to the engine but also may result in personal injury.

Always Use Mitsubishi Genuine Parts

Be sure to use Mitsubishi genuine parts for Mitsubishi engines. DO NOT use imitation parts.

Also, be sure to use fuel, engine oil, and LLD which recommended in this manual.

Observe Safety Rules at Work Site

Observe the safety rules established at your workplace.

Do not operate the engine if you are not feeling well. Inform your supervisor of your condition. Operation of the engine with reduced attentiveness may cause improper operation that could result in accidents. When working in a team of two or more people, use specified hand signals to communicate among workers.

Wear Proper Work Clothing and Protective Gears

Wear a hard-hat, a face shield, safety shoes, a dust mask, gloves, ear plugs, and other protective gears as needed. When handling compressed air, wear safety goggles, a hard-hat, gloves, and other necessary protective gears. Working without wearing proper protective gears may result in serious injury.

Never Break the Seals

To ensure proper engine operation, the fuel control links are sealed to prevent the injection volume and rotational speed settings from tampering. Removing these seals of the engine will void the warranty. The following problems may occur if these seals are removed.

- ♦Rapid wear of moving and rotating parts
- ♦Failures such as seizure and damage of engine parts
- ♦Sudden increase of fuel and lubricating oil consumption
- ♦Poor engine performance due to improper balance between fuel injection volume and governor control, or a serious accident due to overrunning of the engine

Performance of Pre-operation Inspection and Periodic Inspections

Be sure to perform the everyday check-up (pre-operation inspections) and periodic inspections as instructed in this manual.

Failure to conduct the everyday check-up (pre-operation inspections) or periodic inspections and maintenance may result in many problems and damage to various parts of the engine, serious accidents, and deterioration of exhaust gas.

Engine Break-in

For the first 50 hours of operation of a new engine or the engine that has been overhauled, operate the engine under a light load for break-in.

Operating a new engine or an engine that has been overhauled under a severe condition during break-in will shorten the service life of the engine, because the engine parts are not well lubricated and warmed up yet.

Warming Up Engine First

After starting the engine, run the engine at a low idling speed until the coolant temperature reaches approximately 50°C [122°F]. Start the actual engine operation after warming up operation is completed. (Except for the emergency generator which requires a rapid starting. Refer to the technical manual of auxiliary devices for rapid starting.)

The warm-up operation circulates lube oil through the engine and contributes to a longer service life and economical operation.

However, do not perform the warm-up operation for longer than necessary. It may cause accumulation of carbon in the cylinder, and cause faulty combustion.

Cool Down the Engine Before Stopping

Before stopping the engine, operate the engine at a low idle speed for 5 to 6 minutes to cool down.

Stopping the engine immediately after high-load operation will cause engine parts to heat up, and shorten the service life of the engine.

During cooling operation, check the engine for abnormalities.

Do Not Operate the Engine in an Overloaded Condition

If overload symptoms such as black exhaust smoke is observed, reduce the load immediately and assure the proper output and load.

Overloaded operation may cause not only excessive fuel consumption but also excessive carbon deposits. Carbon deposits cause various problems, and will shorten the service life of the engine.

Limitation of Continuous Under Light Load Operation

Allowable minimum load during continuous operation:

Operate with 30% or more of the rated output. Allowable continuous operation time with a load factor of 30% or less of the rated output: Limit the operation within one hour. Operate with a load factor of 50% or more for 30 minutes or more after continuous operation with 30% or less of the rated output is conducted. The following problems may occur when light load operation is conducted beyond the above allowable range:

- ♦Fuel and/or oil leak from the exhaust system
- ♦Carbon build-up on the cylinder head and exhaust pipe
- ♦Sulfuric acid corrosion
- ♦Dilution
- ♦Generation of blue-white smoke (mainly during low idle operation)

Do Not Splash Water on Engine

Do not allow water or rainwater to enter the engine through the air inlet or exhaust opening.

Do not wash the engine during operation. Cleaning fluid (water) may be sucked into the engine.

If the water enters into the combustion chambers, the internal engine may be damaged due to water hammer, and result in a serious accident.

Pre-cleaner Maintenance Precautions

For the maintenance of engine equipped with pre-cleaner, be sure to observe the instructions below:

- ♦Wash the pre-cleaner periodically. If the pre-cleaner is clogged, exhaust temperature will increase because sufficient intake air for combustion is not supplied, and as a result, a failure may occur.
- ♦Never service the pre-cleaner during engine operation. The turbocharger may suck foreign substances into the engine, and could result in serious accidents.
- ♦When removing the pre-cleaner, take care so that foreign substances accumulated on the pre-cleaner will not enter the inside of the engine. When the pre-cleaner is removed, immediately cover the air inlet with a plastic film and others to prevent foreign substances from entering the engine.

Use Proper Tools for Maintenance Work

Always keep in mind to select most appropriate tools for the work, and use them correctly. If a tool is damaged, replace it with a new one.

Do Not Operate Starter for a Long Duration

Do not operate the starter for more than 10 seconds at a time. If the engine does not start, wait for at least 1 minute before cranking again.

Continuous operation of the starter may drain the battery power or cause the starter to seize.

Do Not Turn Off the Battery Switch During Operation

Do not turn off the battery switch during operation.

If the battery switch is turned off during operation, it will stop the engine and the activation of instruments, and may deteriorate alternator diode and transistor.

Engine Transportation Precautions

When transporting the engine on a truck, consider the engine weight, width, and height to ensure safety.

Observe the road traffic law, road vehicles act, vehicle restriction ordinance, and other pertinent laws.

Do Not Turn Engine to Reverse Direction

When rotating the engine by hands, be sure to rotate the engine in its normal rotation direction. If the engine is rotated in the opposite direction, the sea water pump impeller will be broken.

Operate Clutch at Low Idling Speed

When switching between forward and reverse (clutch operation), lower the engine speed and perform idling at either N (Neutral) ↔ F (Forward) or N (Neutral) ↔ R (Reverse). If the clutch operation is performed while rotating at high speed, the marine gear may be damaged.

Shift Clutch Properly

When shifting the clutch, be sure to securely place the clutch in position, F (Forward), R (Reverse) or N (Neutral). If the clutch lever is not firmly engaged in one of these positions, there is a risk for wearing or burning of clutch plates by slipping.

Warning/Caution Labels



Maintenance of Warning/Caution Labels

Make sure that all warning/caution labels are legible. Clean or replace the labels when the description and/or illustration are not clear to read.

- Illegible labels fail to alert people, which may cause personal injury, environmental pollution, and damage to the engine.
- For cleaning the labels, use a cloth and soapy water. DO NOT USE CLEANING SOLVENTS, GASOLINE, OR OTHER CHEMICALS THAT MAY ERASE THE PRINT OR CAUSE PEELING OFF OF THE LABEL. If the labels are damaged, replace them with new ones.
- When replacing a part that has a label attached, attach the new label to the new part so that it is in the same state as before replacement.
- New labels are available at your MHIET dealer, MHIET group company, or MHIET.

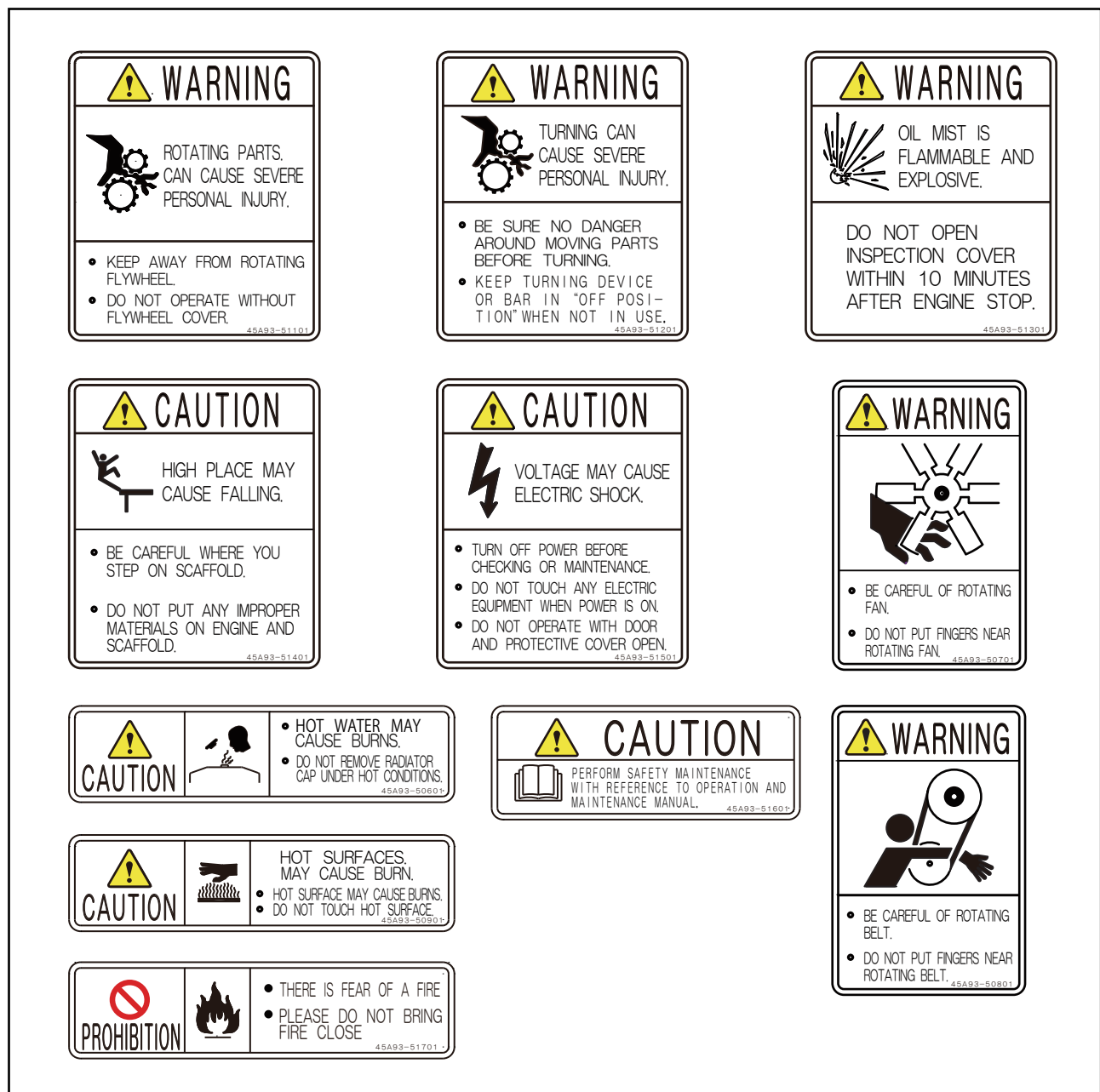


Fig. 1-1 Common Warning/Caution Labels

Chapter 2 NAMES OF PARTS

Engine External Views

This external diagram shows the standard type of the engine. The type and shape of each equipment may vary depending on the specifications.

Front View

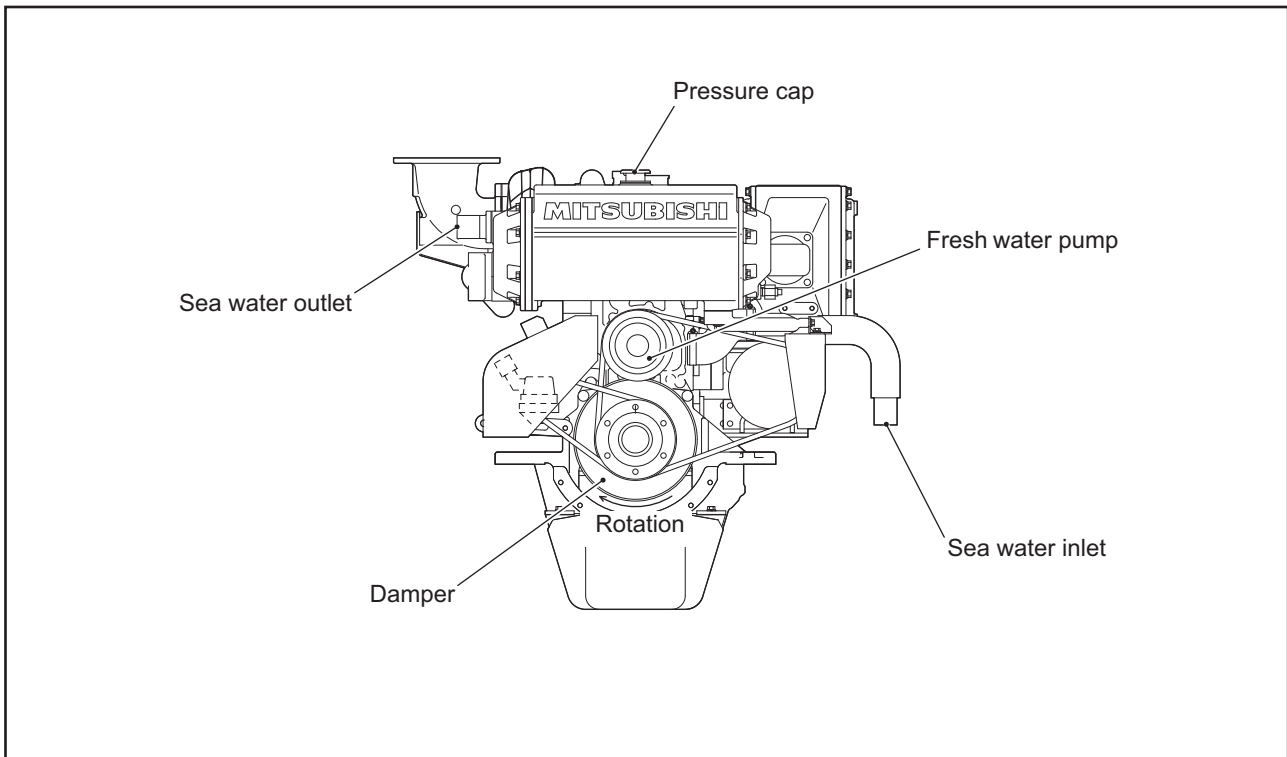


Fig. 2-1 Engine Front View

Rear View

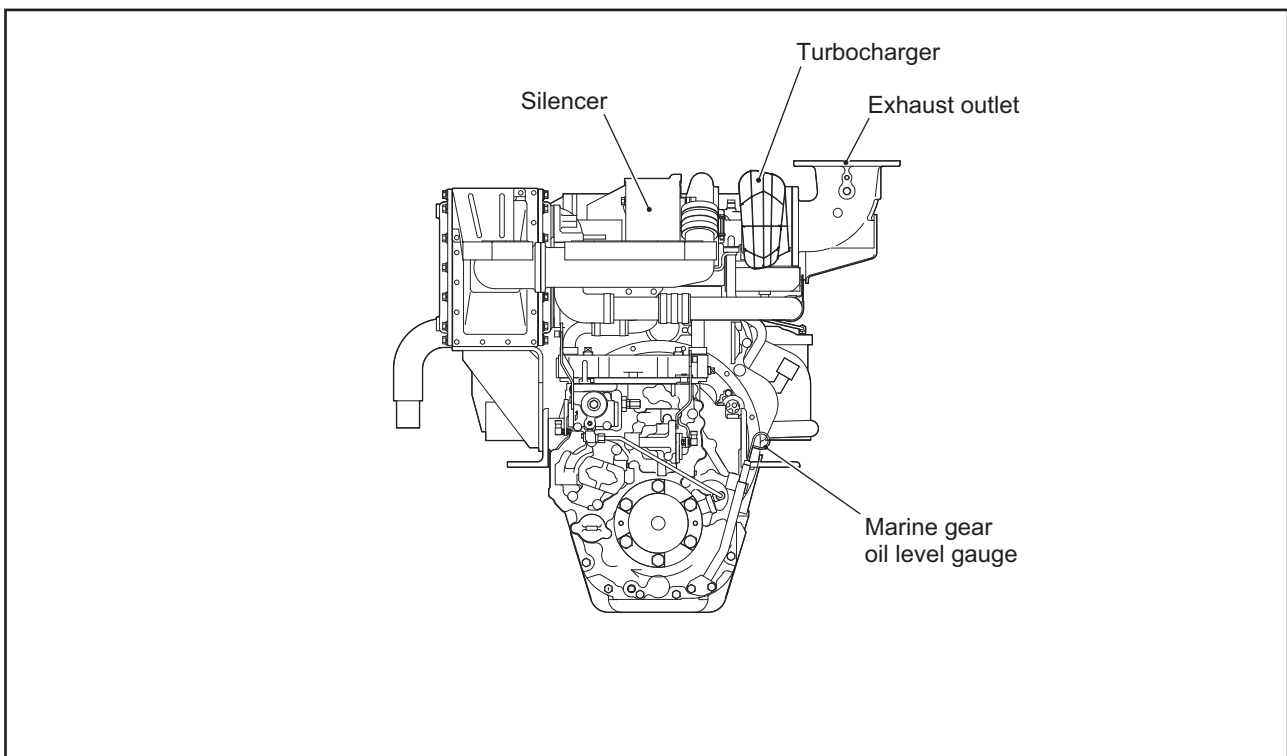


Fig. 2-2 Engine Rear View

Left View

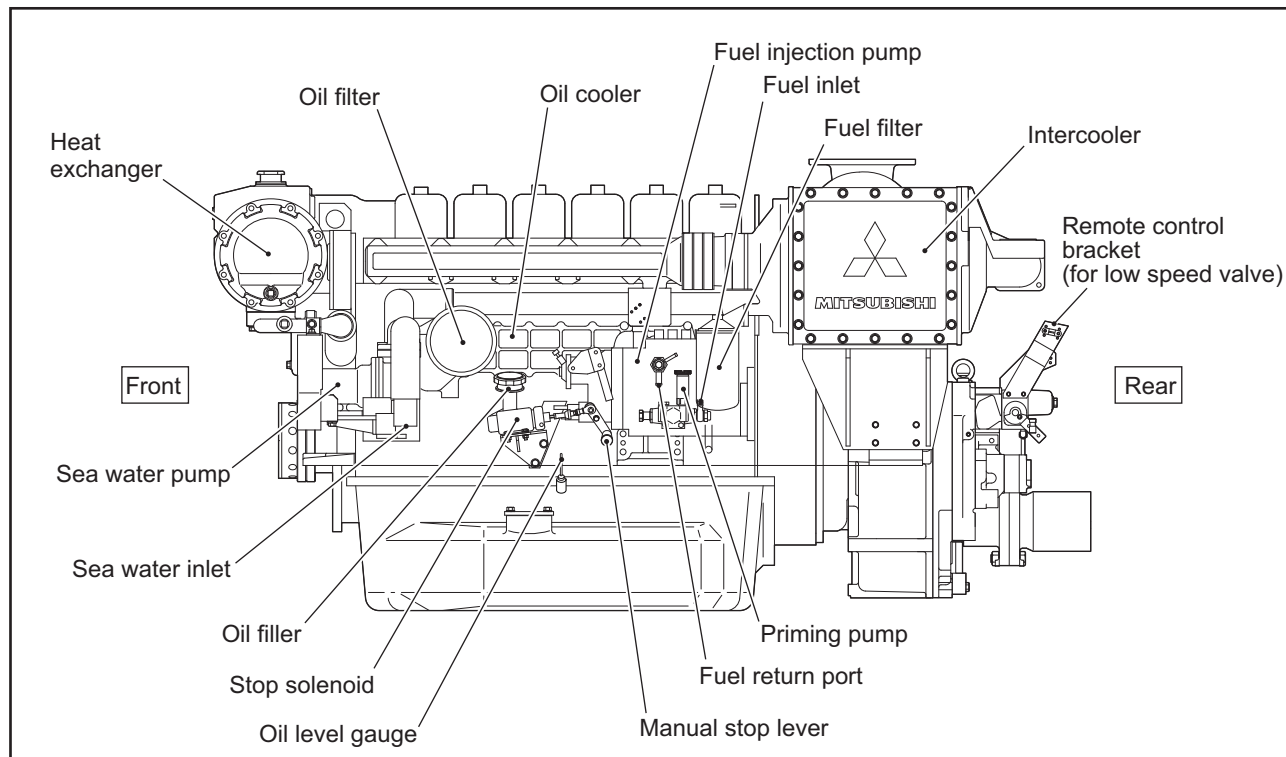


Fig. 2-3 Engine Left-Side View

Right View

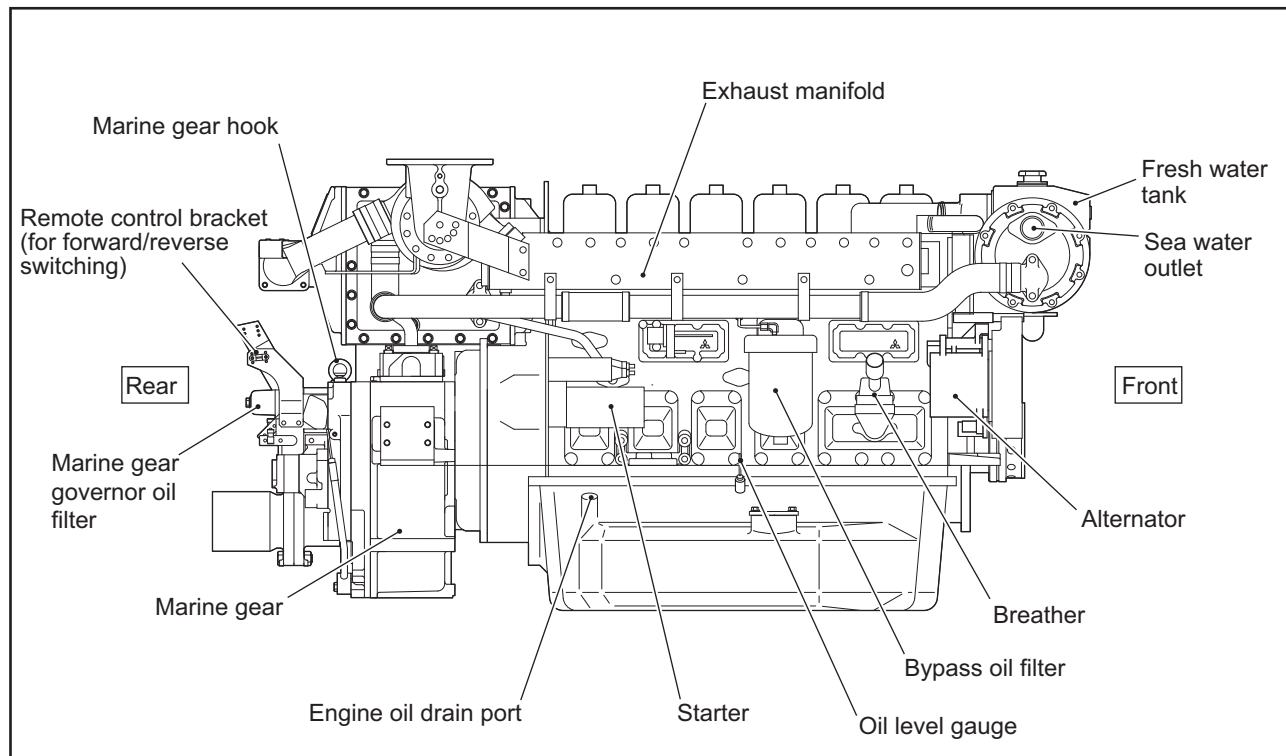


Fig. 2-4 Engine Right-Side View

Operating Devices

Speed Control Lever

The engine rotational speed can be adjusted with the speed control lever.

To increase the rotational speed, turn the lever to H (high-speed rotation) side and to decrease, turn the lever to L (low-speed rotation) side. The rotational speed can be adjusted over the full range of engine rotational speeds.

When you rotate the lever clockwise, the lever is locked in that position (speed).

To release the lock and move the lever, rotate the lever counterclockwise. When you lock, be sure to rotate the lever fully clockwise so as not to come loose due to vibrations, etc.

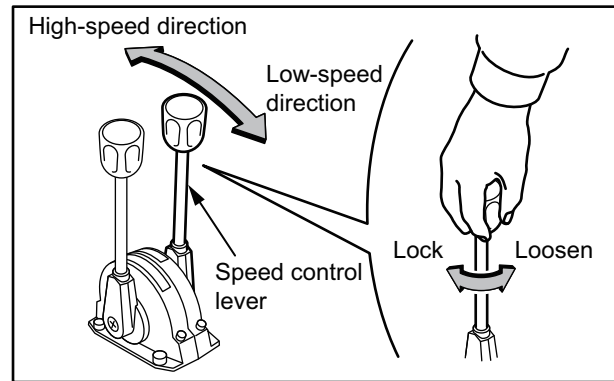


Fig. 2-5 Speed Control Lever

Direction Lever

CAUTION

When shifting the clutch, be sure to securely place the clutch in position, F (Forward), R (Reverse) or N (Neutral). If the clutch lever is not firmly engaged in one of these positions, there is a risk for wearing or burning of clutch plates by slipping.

The marine gear can be shifted to F (Forward), R (Reverse), or N (Neutral) position with the direction lever.

Note: When the engine is equipped with a starter interlock, the lever must be placed in the N (neutral) position to start the engine.

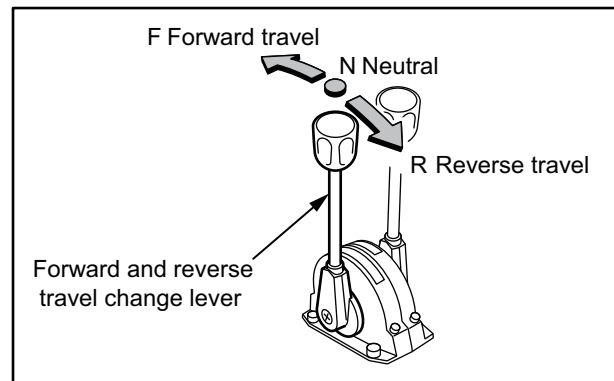


Fig. 2-6 Direction Lever

Stop Button

Press and hold the stop button until the engine completely stops.

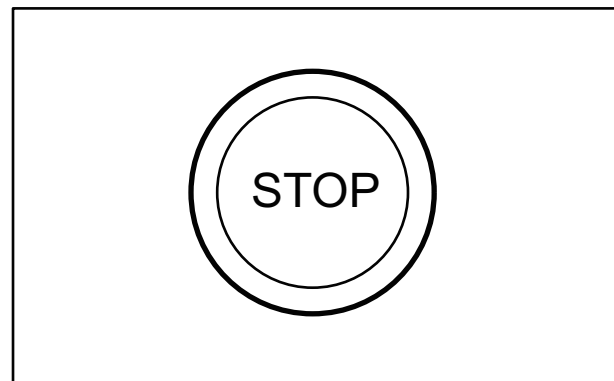


Fig. 2-7 Stop Button

Manual Stop Lever

The manual stop lever is provided to stop the engine when the engine will not stop with the stop button.

The manual stop lever is mounted on the fuel control link unit. You can stop the engine by operating this lever in the "STOP" direction.

If the engine will not stop even after operating the lever in the "STOP" position, cut off the fuel supply to the engine.

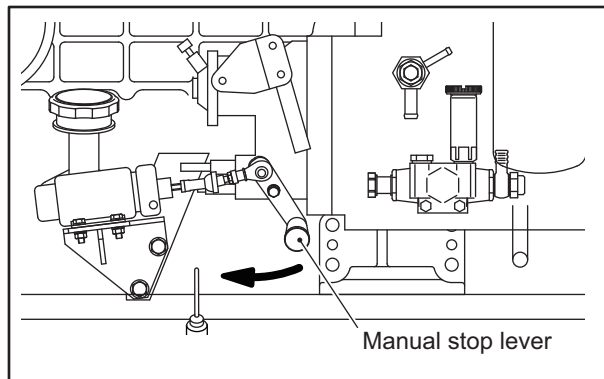


Fig. 2-8 Manual Stop Lever

Transmitters for Instruments

The engine is equipped with the devices which transmit signals to instruments and equipment for operation. Be sure to understand the role of these devices.

Oil Pressure Unit

Detects the oil pressure.

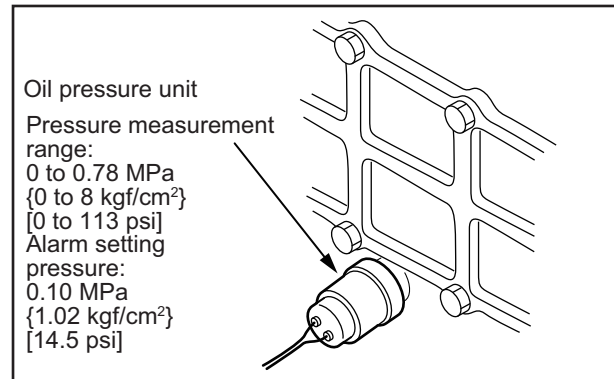


Fig. 2-9 Oil Pressure Unit

Thermo Unit

Detects the engine coolant temperature.

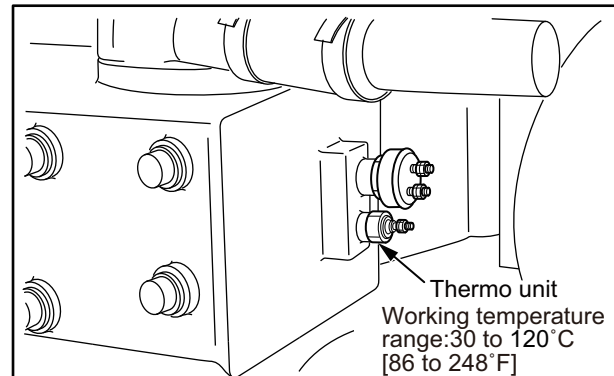


Fig. 2-10 Thermo Unit

Rotation Detection Pickup

It is installed in the timing gear case, and always detects engine speed.

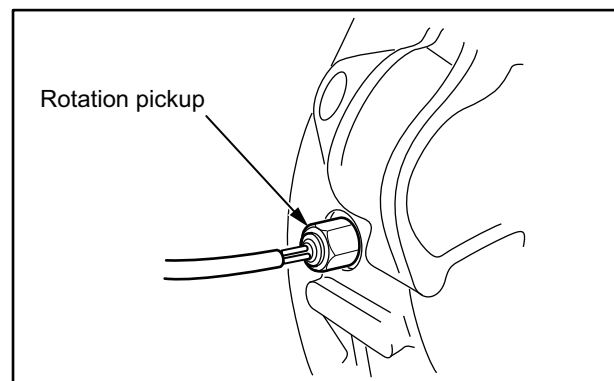


Fig. 2-11 Rotation Detection Pickup

Engine Protection Devices

Thermo Switch

Thermo switch activates an alarm when the engine coolant temperature reaches the higher limit of temperature.

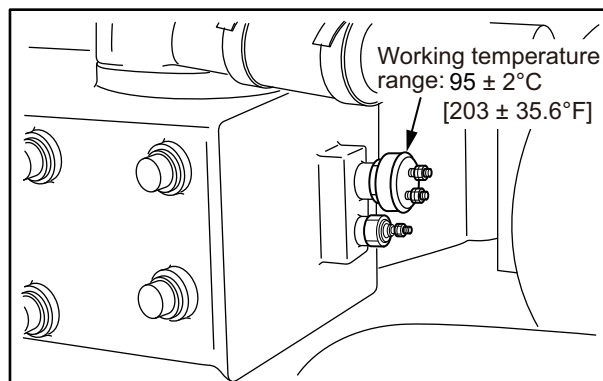


Fig. 2-12 Thermo Switch

Oil Filter Alarm Switch

It activates an alarm when the oil filter becomes clogged and increased pressure difference at the oil inlet/outlet reaches the set value.

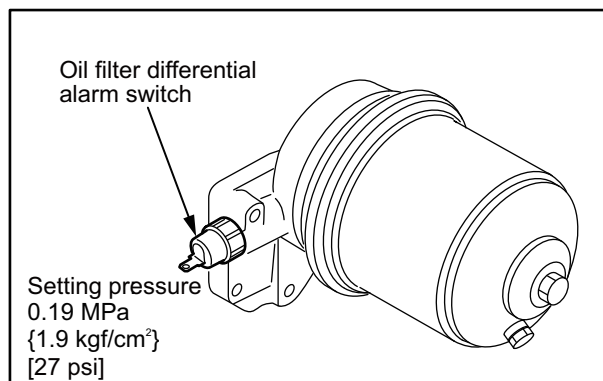


Fig. 2-13 Oil Filter Differential Pressure Alarm Switch

Instrument Panel

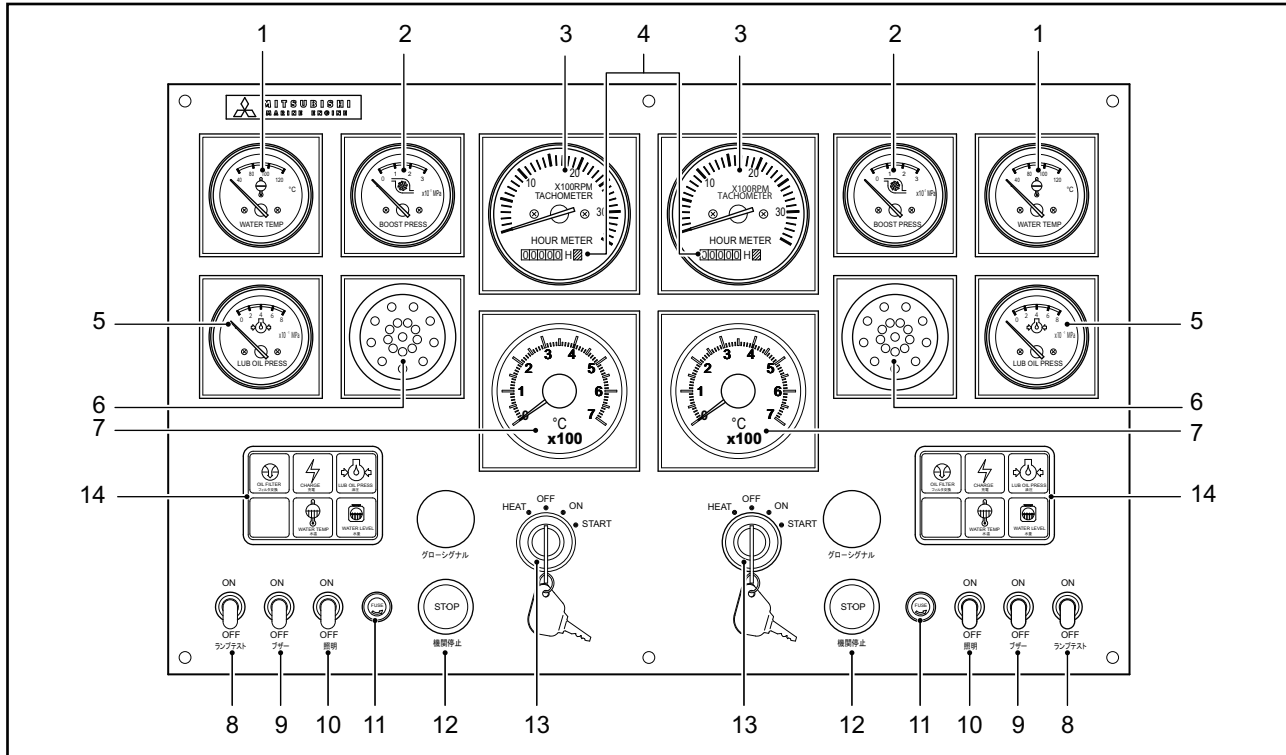
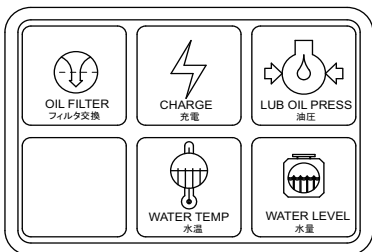


Fig. 2-14 Instrument Panel
Table 2-1 Instrument Panel

No.	Name	Function
1	Coolant temperature gauge	Indicates the temperature of engine coolant (freshwater). (Standard temperature at rated speed: 70 to 80°C [158 to 176°F]) If the gauge indicates 95°C [203°F] or above, the engine is overheating.
2	Manifold pressure gauge	Indicates the engine manifold air pressure.
3	Engine speed meter (Tachometer)	Indicates the rotational speed of engine (RPM).
4	Accumulated operating hour meter (Hour Meter)	Indicates the operating hours of engine. Used as a target for maintenance intervals. Note that the hour meter counts time if the starter switch is in the "ON" position even when the engine is not running. Be sure to turn the starter switch to the "OFF" position when the engine is not running.
5	Lubricating oil pressure gauge	Indicates the engine oil pressure. (Standard at the rated speed: 0.44 to 0.59 MPa {4.5 to 6.0 kgf/cm ² } [64 to 86 psi]) (When warming or warmed)
6	Buzzer	To protect the engine, the warning buzzer goes off when either of the following conditions occurs: Abnormal rise in coolant (freshwater) temperature and abnormal decrease in lubricating oil (pressure). Also the warming light (coolant temperature light, oil pressure light) illuminates.
7	Exhaust temperature gauge	Indicates the engine exhaust temperature.
8	Lamp check switch	When the starter switch is in the "ON" position, turn this switch ON to make sure the warming lamp will glow. Check this during start-up inspection.
9	Buzzer stop switch	When the warning buzzer sounds, turn this switch OFF to stop the buzzer. Always keep this switch in the "ON" position during operation.
10	Illumination switch	Turn this switch ON to illuminate gauges.

Table 2-1 Instrument Panel

No.	Name	Function
11	Fuse	A barrel type 3A fuse is located inside the cap. If the warning lamp does not glow even when the starter switch is turned to the "ON" position, the fuse may have blown. Check the fuse, and if it has blown, replace it with a new one.
12	Stop button	Keep pressing the stop button until the engine stops. (about 10 seconds)
13	Starter switch	HEAT (Preheat): To make starting easier during cold season, turn the key to the "HEAT" position before turning to the "START" position to warm the air heater. "OFF" (Switch OFF): Return the key to the "OFF" position after you stop the engine. The key can be removed or inserted in this position as the supply of electric current to the circuits of gauges is stopped. "ON" (Switch ON): Place the key in this position after the engine has started (during operation). Electricity flows through the electrical circuits of gauges and warming indicators. "START" (Start-up): Turn the key to the "START" position to start the engine. Release the key when the engine has started. The key automatically returns to the "ON" position.
14	Warning light	Filter warning light (oil filter clogging warning light) The light comes on when oil filter is clogged. Replace oil filter when the light comes on. (Oil filter alarm switch ON: Pressure difference across the oil filter is 0.19 MPa {1.9 kgf/cm²} [28 psi]) Charge warning light (battery charge fault light) The light glows when a fault is detected in charging system. Check the charging system if this lamp glows. Note: Note that this light normally illuminates for several seconds immediately after starting the engine.
	Water temperature warning light (coolant temperature rise warning light) Illuminates when the fresh water coolant temperature rises abnormally. If this light illuminates, run the engine at minimum idling speed, and then stop the engine. Check the cooling system after the engine has cooled down. (Temperature at which thermo switch turns ON: 95°C [203°F]) Note: The warning buzzer will goes off when the oil pressure warning light or water temperature warning light comes on.	Oil pressure warning light (lubricating oil pressure drop warning light) The light glows when the lubricating oil (engine oil) pressure drops abnormally. Stop the engine immediately, and check the lubricating system. (Lubrication oil pressure drop switch ON : 0.25 to 0.5 MPa {0.25 to 0.05 kgf/cm²} [36 to 7 psi]) Water level warning light (low oil level light) This warning light is not available.



Preparation for Operation of New or Overhauled Engine

For new engines or overhauled/reassembled engines, the operation is different from normal. As for a new engine, conduct the following checks before starting the first operation. As for a overhauled engine (when either main bearing, connecting rod bearing, piston ring, or cylinder liner has been replaced), conduct "[Preparation of Operation for Overhauled Engines](#)" (3-7). For second operation onward, follow the instructions described in the "[Normal Engine Operation](#)" (3-9).

Preparation of Fuel System

⚠ CAUTION

When handling fuel, make sure there are no open flames or other fire hazards near the engine.
Wipe off any spilled fuel completely. It may cause a fire.

CAUTION

Do not remove the strainer during fuel tank filling.
For the fuel to be used, refer to "[FUEL](#)" (4-1).

Bleeding the Fuel System

⚠ WARNING

When fuel overflows from the air vent plug, wipe thoroughly with a cloth. Spilled fuel can cause a fire.
After bleeding air, lock the priming pump securely. If lock is loose, the priming pump may be damaged, and a fire may occur from fuel leaking.

While feeding fuel with the priming pump, bleed air from the location closest to the fuel tank, that is, in the order of the water separator, fuel filter, and fuel injection pump.

Priming Pump Cap - Handling

1. Turn the priming pump counterclockwise to unlock.
2. Move the priming pump up and down several times to feed fuel and bleed air.
3. After bleeding air, turn the priming pump clockwise to lock. Be sure to lock securely.

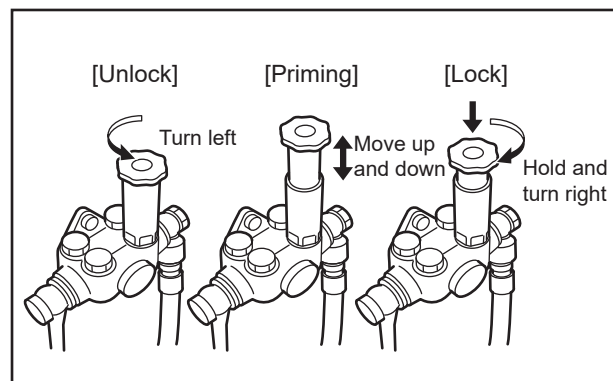


Fig. 3-1 Priming Pump Cap - Handling

Fuel Filter - Bleed Air

CAUTION

If the air vent plug, the threaded portion of the bracket and the sealing washer are damaged, replace with a new one.

1. Loosen the air vent plug of the fuel filter about one turn.
2. Move the priming pump up and down to pump fuel.
3. When bubble-free fuel comes out from the air vent plug, tighten the air vent plug to the specified torque.

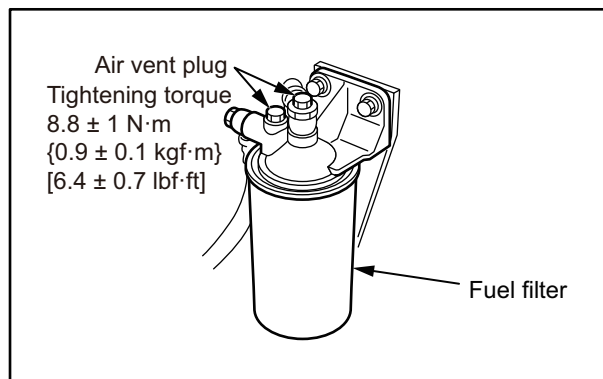


Fig. 3-2 Fuel Filter - Bleed Air

Fuel Injection Pump - Bleed Air

1. Loosen the air vent plug on the fuel injection pump by rotating about 1 turns.
2. Move the priming pump up and down. When the fuel flow from the air vent plug becomes free of bubbles, turn the priming pump clockwise while pushing it to lock.
3. Tighten the air vent plug on the fuel injection pump.

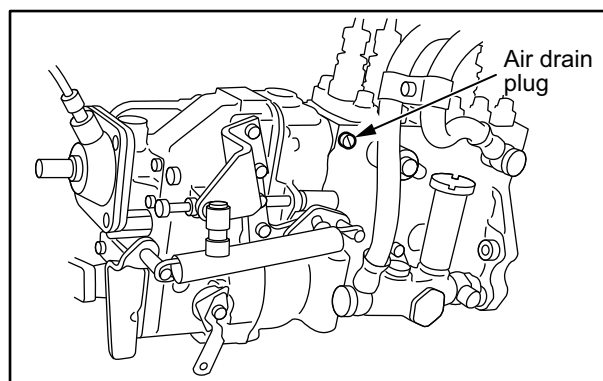


Fig. 3-3 Fuel Injection Pump - Bleed Air

Preparation of Lubrication System

Engine Oil - Refill

CAUTION

When filling the engine oil, maintain the proper amount of oil. If the oil level is higher than the high mark on the level gauge, engine oil may blow out during operation. Also, the rise in oil temperature may adversely affect engine components.

1. Remove the oil filler cap.
2. Refill the specified engine oil to the specified level.

Note: For engine oil, refer to **"ENGINE OIL" (5-1)**. For engine oil capacity, refer to **"MAIN SPECIFICATION" (12-1)**.

3. Check the oil level in the oil pan.
4. Wipe the oil level gauge clean with a waste cloth.
5. Insert the oil level gauge fully into the oil level gauge guide and then pull it out again.
6. It is normal if the oil level is between the high and low marks on the oil level gauge. If the oil level is low, refill the specified engine oil.
7. Check for oil leaks from the oil pan. Repair it if any leaks are found.
8. With the manual stop lever placed in pulled position, crank the engine with starter for approximately 10 seconds to circulate oil to all parts of the engine. Pause for about 1 minute and repeat the same operation two or three times to circulate engine oil to all parts of the engine.

Note: Also, perform the items described under the Preparation of Cooling System.

9. Start the engine and run at low idle speed with no load for 5 to 10 minutes.
10. After stopping the engine and leaving it for 30 minutes or more, check the oil level again with the oil level gauge and refill oil to the specified level. For details, refer to **"Test Operation" (3-6)**.

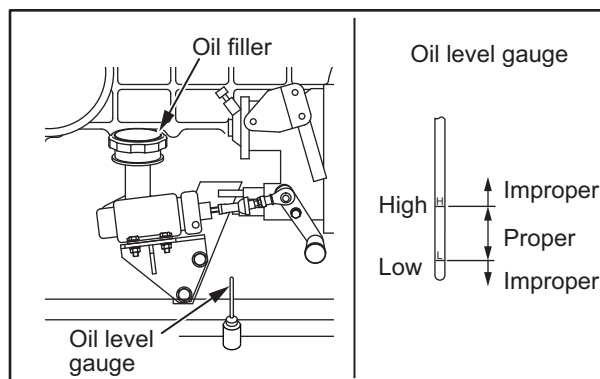


Fig. 3-4 Oil Filler and Oil Level Gauge

Preparation of Cooling System

Fresh Water Tank Pressure Cap - Open/Close

CAUTION

Never open the Fresh water tank pressure cap during the operation or immediately after stopping. If you open the cap when the coolant is hot, there is a risk of getting burned if steam or boiling water comes out. Stop the engine, and after the coolant has sufficiently cooled down, then, open the cap.

To open the Fresh water tank pressure cap, wear thick rubber gloves, or place a waste cloth over the cap, and turn the cap 1/4 turn to release the internal pressure.

When fastening the Fresh water tank pressure cap, be sure to tighten securely.

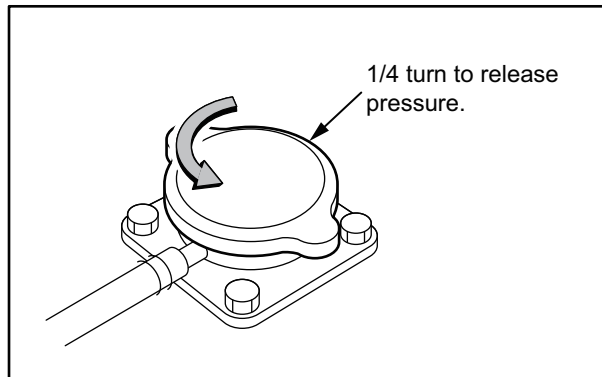


Fig. 3-5 Fresh Water Tank Pressure Cap

Coolant - Refill

CAUTION

To add coolant, use the same LLC concentration coolant that is currently in the cooling system.

1. Securely close the engine coolant drain cock.
2. Open the coolant filler port and add a mixture of water and coolant (LLC) having the specified concentration.

Note: Determine the quantity of LLC based on the coolant capacity and the LLC concentration chart.

For the coolant, refer to "COOLANT" (6-1). For the coolant capacity, refer to "MAIN SPECIFICATION" (12-1).

3. Check the heat exchanger, etc. for coolant leaks. Repair if a leak is found.
4. When the coolant reaches the specified level, securely close the coolant fill port.
5. With the stop device such as a manual stop lever activated, crank the engine for approx. 10 seconds using the starter. Stop for approximately 1 minute, and then repeat the cranking 2 or 3 times to bleed air from the cooling system.

Note: Also, perform the items described under the Preparation of Lubrication System.

6. Check the coolant level.
7. Also, fill the reserve tank with coolant up to the "FULL" level line.

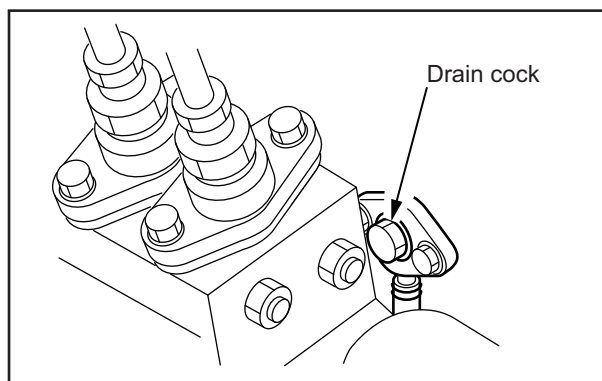


Fig. 3-6 Coolant Drain Cock (Engine Body)

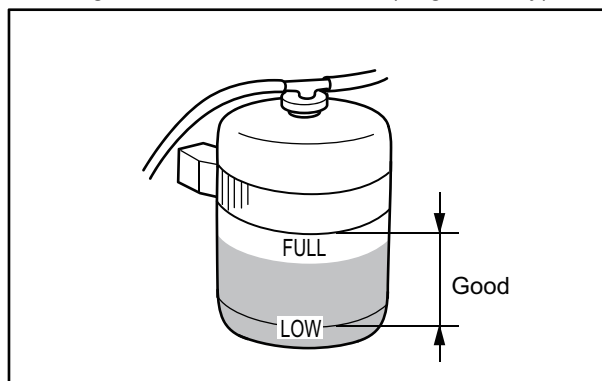


Fig. 3-7 Reserve Tank Coolant Level

Preparation of Electrical System

Battery - Check

⚠ CAUTION

- ♦Never use flames or allow sparks near the battery. The battery releases flammable hydrogen gas and oxygen gas. Any flames or sparks near the battery may cause an explosion.
- ♦Do not use the battery when the battery fluid level is below the "LOWER LEVEL" mark. It may explode.
- ♦Do not short the battery terminals with a tool or other metal object.
- ♦When removing battery, always remove the plug from the negative (-) terminal first. When connecting battery, always connect the plug to the positive (+) terminal first.
- ♦Before charging the battery, remove all battery cables, and then charge the battery in a well-ventilated area.
- ♦Make sure the cable clamps are securely attached to the battery terminals. A loose cable clamp may cause sparks, and it may result in an explosion.
- ♦Before servicing electrical components or conducting electric welding, set the battery switch to the [OFF] position or remove the plug from the negative (-) terminal to cut off the electrical current.
- ♦Battery fluid contains dilute sulfuric acid. Careless handling of the battery may cause a sight loss and/or skin burns. Also, do not swallow the battery fluid.
- ♦Wear protective goggles and rubber gloves when working with the battery (e.g. when adding water or charging battery).
- ♦If battery fluid is spilled onto the skin or clothing, immediately wash it away with lots of water. Use soap to clean thoroughly.
- ♦The battery fluid may cause sight loss if splashing into the your eyes. If it gets into your eyes, immediately flush it away with plenty of clean water, and seek immediate medical attention.
- ♦If you accidentally swallow battery fluid, gargle with plenty of water and then drink lots of water, and seek immediate medical attention.
- ♦If the battery does not fully recover after charging for 24 hours or more, do not use the battery.

Note: If the specification of battery differs from those of this operation manual, follow the battery manufacturer's operation manual.

Battery Fluid Level - Check

The battery fluid evaporates during the use, and the fluid level gradually decreases. The proper fluid level is between the LOWER LEVEL (Lower limit) and UPPER LEVEL (Upper limit) marks.

For the battery without level marks, the proper fluid level is about 10 to 15 mm [0.39 to 0.59 in.] above the top face of the polar plates.

If the battery fluid level is low, remove the cap, and add distilled water to the proper level.

Note: When adding distilled water, add little by little.

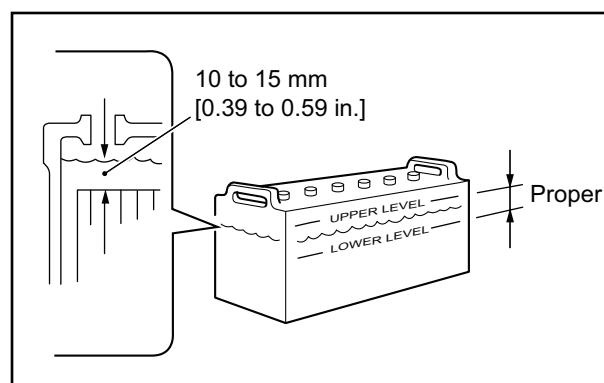


Fig. 3-8 Battery Fluid Level - Check

Test Operation

To conduct the test operation, follow the procedures below:

Note: For engine operation, refer to "Normal Engine Operation" (3-9).

Start and Stop

1. Start the engine.
2. Operate the engine at a low idling speed under no load for 5 to 10 minutes for warm-up.
3. Stop the engine.

Inspection

 CAUTION

Never open the Fresh water tank pressure cap during the operation or immediately after stopping. Stop the engine and, after coolant has sufficiently cooled down, open the cap.

To open the Fresh water tank pressure cap, place a waste cloth over the cap, and loosen it about a quarter-turn to release the internal pressure.

The coolant is extremely hot while the engine is running and immediately after the engine stops. Do not open the cap when the coolant is hot. Otherwise you may get burned by a splash of hot steam and water. To avoid a steam burn, wear thick rubber gloves or wrap a cloth around the cap.

When fastening the Fresh water tank pressure cap, be sure to tighten securely.

CAUTION

When adding coolant, use the same LLC concentration coolant that is currently in the cooling system.

1. Stop the engine for about 30 minutes.
2. During this period, walk around the engine to check for leaks of fluids such as fuel, engine oil, or coolant.
3. Then 30 minutes later after the engine has stopped, check the oil level with the oil level gauge.
4. If the oil level is low, add engine oil from the oil filler port. Be sure to use the engine oil of the same brand and type.
5. Open the Fresh water tank pressure cap and check the coolant level.
6. If the coolant level is low, add coolant to the specified level.
7. Also fill the reserve tank with coolant up to the "FULL" level line.

Preparation of Operation for Overhauled Engines

When either main bearing, connecting rod bearing, piston ring, or cylinder liner has been replaced, conduct the break-in operation as follows:

Preparation Before Engine Starting

- ♦ Check the amount of fuel, engine oil, coolant, and then bleed the fuel system and cooling system.
- ♦ Remove the breather pipe at an arbitrary position.
- ♦ Inspect the link from governor output lever to the fuel injection pump rack. Make sure that the control rack is in the non-injection position when stopped and that the control rack is "0" by operating the stop lever.
- ♦ Check the wiring of electrical system (sensor, meter alarm panel, starter, alternator, stop solenoid, battery), turn on the main switch of the controller and confirm that there is no abnormality. Set the speed lever position of the governor so that the engine runs at a low idle speed after the start-up.
- ♦ Activate the stop solenoid and confirm that the fuel injection pump rack is in the predetermined non-injection position.
- ♦ Install the pressure gauge, thermometer, and flow meter as required.

Engine Start-up

1. While pulling the stop lever to the non-injection position, turn the starter for about 10 seconds 2 or 3 times (pause for 1 minute or more) to rotate the crankshaft and circulate engine oil to each part of the engine. At this time, check that there is no abnormality such as abnormal noise and rotational fluctuation.
2. Start the engine with normal startup operation. Confirm that the engine runs at a low idle speed after start-up.
3. Make sure that hydraulic pressure rises immediately and coolant circulates.
4. Check that there is no leakage of lubricating oil, coolant, and fuel, leakage of gas (air), abnormal noise, abnormal vibration.
5. After making sure the engine is running at the low idle speed without any problem, stop the engine.

Break-In Operation

CAUTION

Be prepared for emergency stop operation in preparation for unexpected trouble during engine operation.

Break-in Load and Time

The load during break-in operation shall be increased progressively as shown in the table below. Note that the time shown in the table is the minimum time required to check the engine in a stable condition.

Table 3-1 Break-In Operation

Break-In Operation				
	Rotational speed (min ⁻¹)		Load factor	Duration (min)
1	Low rotating speed	600 to 900	No-load	20
2	Medium rotating speed	1000 to 1200	No-load	10
3	High rotating speed	1400 to rated speed	No-load	10
4	Rated speed with load	Equivalent to 25% output	25%	20
5		Equivalent to 50% output	50%	20
6		Equivalent to 75% output	75%	30
7	Rated speed with load	Equivalent to 100% output	100%	20

Engine - Inspect During Operation

During the break-in operation, pay attention to the followings and make sure that there is no abnormality.

- ♦Oil pressure and oil temperature
- ♦Coolant temperature and level
- ♦Fluid leaks such as oil, coolant, and fuel, especially oil leaks from turbocharger lubricating pipe mounting section
- ♦Noise and vibration
- ♦Intake air pressure and intake air temperature
- ♦Exhaust color and odor
- ♦Exhaust gas temperature
- ♦Blow-by gas (amount and color)
- ♦Rotational fluctuation
- ♦Surface runout of rotating part and runout
- ♦Indication and operation of meters and warnings

After Break-in Operation - Inspection and Adjustment

- ♦Valve clearance (when cold)
- ♦Fuel injection timing
- ♦External bolts and nuts - retighten
- ♦Belt tension
- ♦Investigation and correction of abnormal parts such as oil leak

Normal Engine Operation

This section covers the procedures for the engine operation in normal condition.

CAUTION

If an engine abnormality is observed during operation, stop the engine and correct the problem, or contact your MHIET dealer.

Pre-operation Inspection

Always conduct daily pre-operation inspection before starting the engine for the day.

Engine Exterior - Inspection

CAUTION

Check external parts of the engine, particularly hot parts (exhaust manifold and others), or the battery for accumulation of flammable materials. Also, check leaks of fuel and engine oil. Remove dust from the top surface of the battery. If hot parts have a problem, it may cause a fire. If any abnormality is found, be sure to repair or contact your MHIET dealer.

Inspect the engine exterior as instructed below:

1. Make sure there is no combustible material near the engine or battery. Also, check to make sure that the engine and battery are clean. If combustible materials or dust are found near the engine or battery, remove them.
2. Make sure fluids, such as fuel, oil, and coolant, are not leaking from the engine. If a leak is found, repair the leak, or contact your MHIET dealer.
3. Walk around the engine and check bolts and nuts for looseness.
4. Check electric wiring for disconnection, looseness, cuts, or rubbing.
5. Make sure the following valves, plugs, or cocks are properly positioned as indicated below:
 - Fuel feed valve: open
 - Coolant drain cock (valve): closed
 - Engine oil drain plug: closed

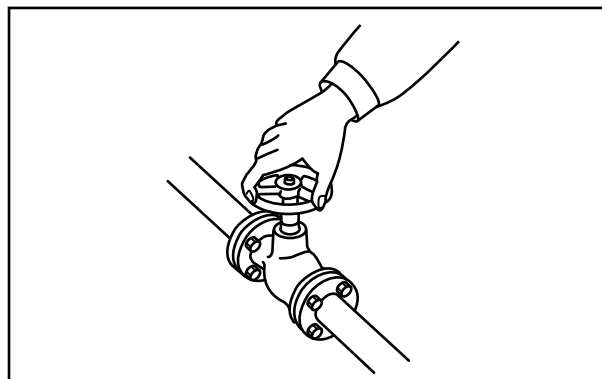


Fig. 3-9 Valve Open/Closed Position - Check

Fuel Tank Oil Level - Check

⚠ WARNING

Make sure that there is no open flame in the vicinity before handling fuel.

Wipe off any spilled fuel completely. It can cause a fire.

CAUTION

Do not remove the strainer during fuel tank filling.

For the fuel to be used, refer to ["FUEL" \(4-1\)](#).

Make sure that the fuel tank is filled to the specified level.

If the fuel level is low, add fuel to the "High" level.

Note: If the specification of fuel tank differs from the contents in this operation manual, follow the fuel tank manufacturer's operation manual.

Engine Oil Level - Check

⚠ CAUTION

Refill the engine with oil to the specified level. If the oil level is higher than the H mark on the level gauge, engine oil may blow out during operation. Also, the rise of oil temperature may adversely affect engine components.

When adding engine oil, use the same oil that is used in the engine.

1. Stop the engine and leave it for 30 minutes or more.
2. Pull out the oil level gauge and wipe oil off from the oil level gauge using a clean waste cloth.
3. Insert the oil level gauge fully into the oil level gauge guide and then pull it out again.
4. The oil level should be between the H and L marks on the oil level gauge. If the engine oil level is higher than the high mark on the oil level gauge, drain the oil. If the oil level is low, add the specified engine oil.

For draining engine oil, refer to ["Engine Oil - Drain" \(8-9\)](#). For refilling engine oil, refer to ["Engine Oil - Refill" \(8-11\)](#).

5. Install the oil filler cap after engine oil is refilled.

Note: (a) Before installing the oil filler cap, wipe off engine oil on the oil filler cap and pipe.

(b) Overtightening the oil filler cap may cause damage.

6. Check the oil pan and others for oil leaks.

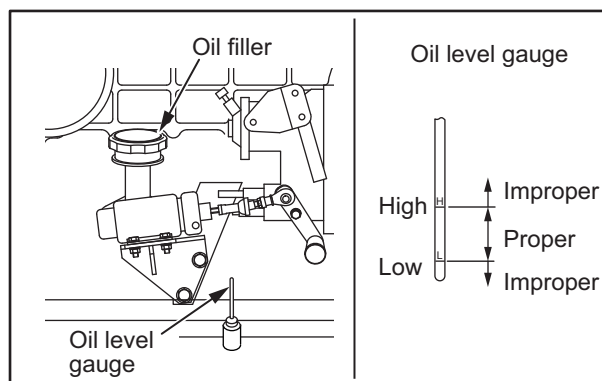


Fig. 3-10 Oil Filler and Oil Level Gauge

Coolant Level - Check

WARNING

Never open the Fresh water tank pressure cap during the operation or immediately after stopping. Open the cap when the coolant has sufficiently cooled down after stopping the engine.

To open the Fresh water tank pressure cap, place a waste cloth over the cap, and loosen it about a 1/4 turn to release the internal pressure.

The coolant is hot while the engine is running and immediately after stopping. If the Fresh water tank pressure cap is opened while the coolant is hot, steam and hot water will blow out and you may get burned. To prevent burn injuries from hot steam, wear thick rubber gloves or wrap a cloth around the cap.

When fastening the Fresh water tank pressure cap, be sure to tighten securely.

CAUTION

When adding coolant, use the same LLC concentration coolant that is currently in the cooling system.

1. Open the Fresh water tank pressure cap and check the coolant level.
2. If the coolant level is low, add coolant to the specified level.

Note: Determine the quantity of LLC based on the coolant capacity and the LLC concentration chart.

For the coolant, refer to ["COOLANT" \(6-1\)](#). For the coolant capacity, refer to ["MAIN SPECIFICATION" \(12-1\)](#).

3. Also fill the reserve tank with coolant up to the "FULL" level line.

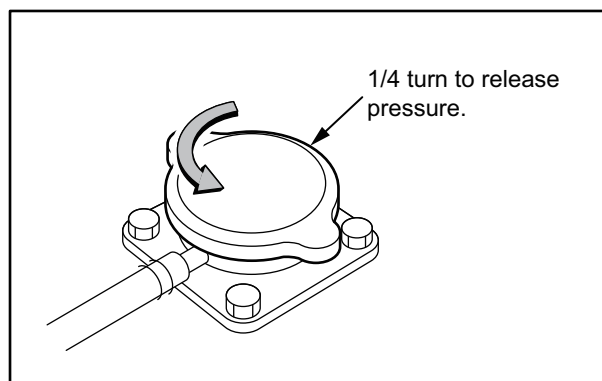


Fig. 3-11 Fresh Water Tank Pressure Cap

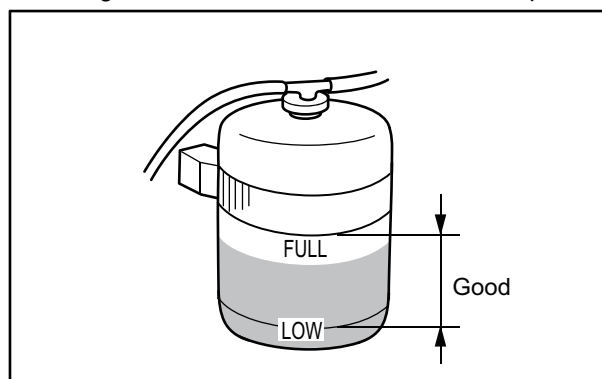


Fig. 3-12 Reserve Tank Coolant Level

Warning Indicator Light - Operation Check

1. Turn the starter switch to the "ON" position.
2. Turn the light test switch to "ON" position.
3. Make sure the lights come on. If any of the lights does not come on, check the light bulbs, etc. on the instrument panel.

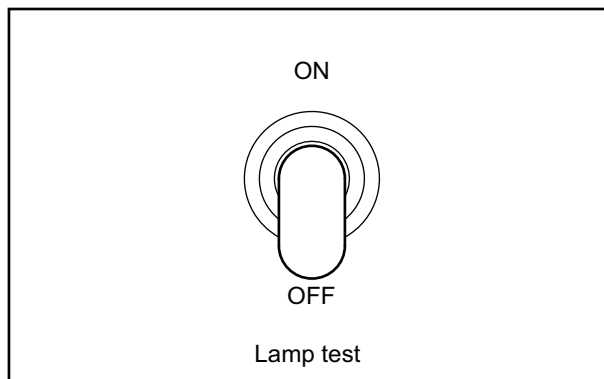


Fig. 3-13 Warning Indicator Light - Operation Check

Control Cable - Check

Check the visual appearance of control cable for flaws, deformation, discoloration, abnormal rust, etc.

Control Lever - Operation Check

Operate each lever and make sure that levers move smoothly without any looseness or restriction.

Operate the speed control lever from L (low-speed rotation) to H (high-speed rotation) and to L (low-speed rotation) position to make sure the operation of lever.

Operate the direction lever, and make sure the marine gear is correctly positioned in the "Forward", "Neutral," and "Reverse" respectively.

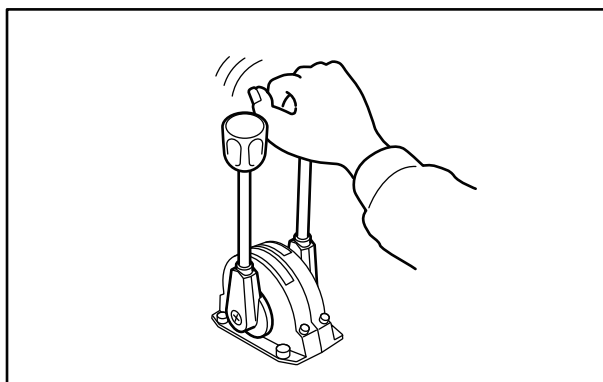


Fig. 3-14 Control Lever - Operation Check

Start-up

Cautions When Starting

WARNING

Before starting the engine, check to make sure no one is near the engine and that tools are not left on or near the engine. Also alert people in the area when starting the engine.

CAUTION

Continuous operation of the starter will drain the battery power and cause the starter to seize. Do not use the starter for more than 10 seconds at a time. When the engine does not start, wait for more than 1 minute before cranking again.

Restart the engine after it stops completely.

Check fuel system if the engine will not start after repeating above step three to five times.

DO NOT turn the switch to "START" or "OFF" position during operation.

When the engine is not operated for a long time (one week or more), rotate the crankshaft for 10 seconds with the starter while pulling the manual stop lever. Repeat this three times with 30-second intervals between each rotation to circulate oil through the engine.

Pre-heating during cold weather should be performed within the specified time given below.

If pre-heating specified time is exceeded, it could decrease battery capacity faster, or shorten the life of air heater.

Table 3-2 Pre-heating Time in Cold Climates (Air Heater)

Ambient temperature	Preheating time
-5°C to -15°C [23°F to 5°F]	20 to 40 seconds
-15 °C to -30°C [5°F to -22°F]	40 to 60 seconds

Starting Procedures

1. Open the Kingston valve.
2. Place the battery switch in the "ON" position.

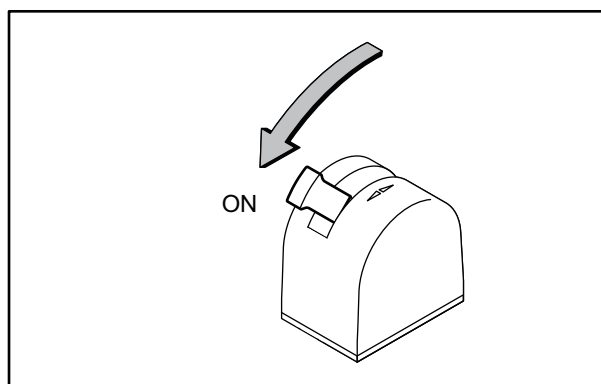


Fig. 3-15 Battery Switch "ON"

3. Place the speed control lever in the middle between "L" (low speed) and "H" (high speed) positions and place the direction lever in the "N" (neutral) position.

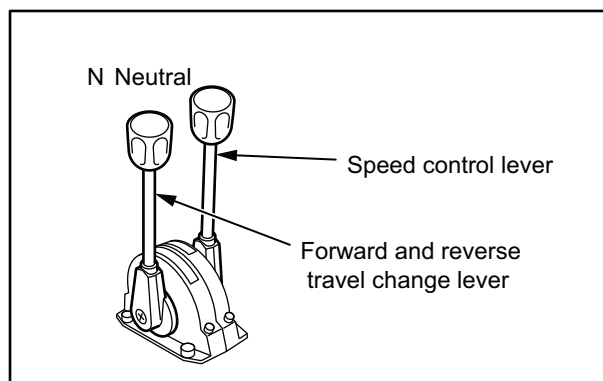


Fig. 3-16 Control Lever Start Position

4. In a cold climate, turn the starter switch key to "HEAT" until the glow signal turns red.

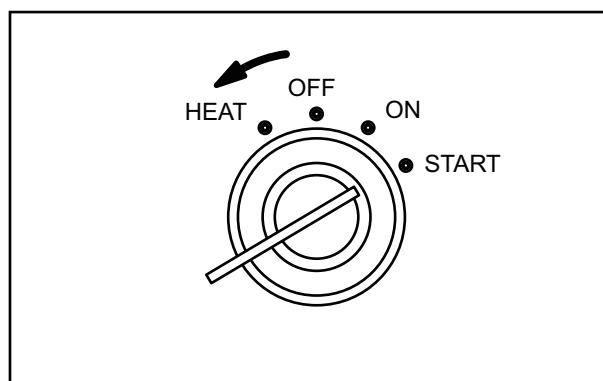


Fig. 3-17 Starter Switch "HEAT"

5. Turn the starter switch key to the "START" position to start the engine.

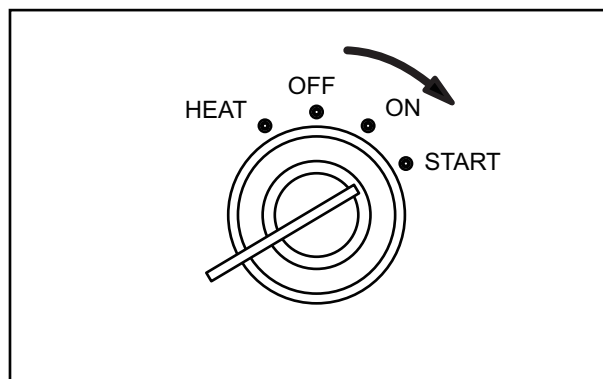


Fig. 3-18 Starter Switch "START"

6. Release the key when the engine has started. The key automatically returns to the "ON" position.

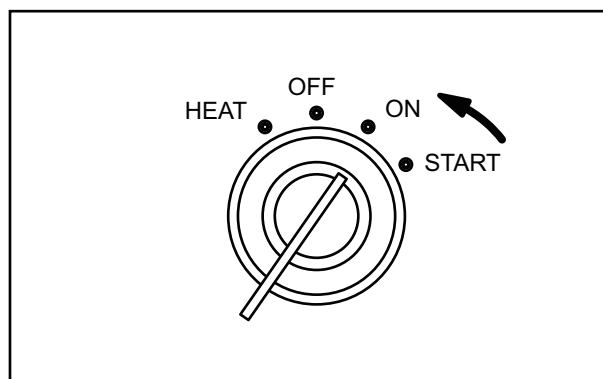


Fig. 3-19 Starter Switch "ON"

Warm-up Operation

WARNING

Stay away from rotating parts during operation. If you are caught in rotating parts, you could be seriously injured.

CAUTION

Do not conduct warm-up operation for extended periods of time. Carbon deposits accumulate in the cylinder and may cause faulty combustion.

During warm-up operation, avoid an overload operation (if overloaded, black smoke is exhausted). Overload operation causes not only excessive fuel consumption but also excessive carbon deposits inside the engine. Carbon deposits cause various problems and will shorten the service life of the engine.

Engine Oil Pressure - Check

While the engine is warming up, check that the engine oil pressure is at the standard value.

Also, check that the engine oil pressure gauge is working properly.

Note: Rev up the engine speed during the low oil temperature, such as immediately after engine start-up, the pressure may exceed the normal operating pressure, but as the oil temperature rises, the pressure becomes the normal operating pressure.

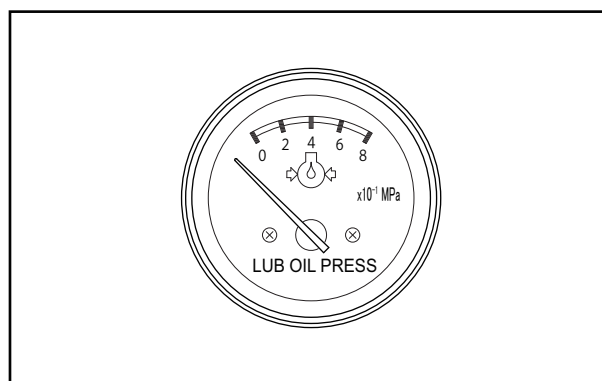


Fig. 3-20 Lubricating Oil Pressure Gauge

Engine - Walk Around Check

Visually inspect the engine for external damage, abnormal noise, odor, vibration, and exhaust gas color, and then inspect for fuel, engine oil, coolant, or exhaust gas leaks from joints during warm-up operation.

Marine Gear Oil Level - Check

1. Pull out the oil level gauge during low idle operation, and wipe the gauge with a clean cloth.
2. Insert the oil level gauge fully into the oil level gauge guide and then pull it out again.
3. The oil level shall be between the maximum and minimum marks on the oil level gauge.
4. If the oil level is low, stop the engine, remove the filler cap, and add the specified oil to the specified level.
5. Check oil leaks from marine gears, etc.

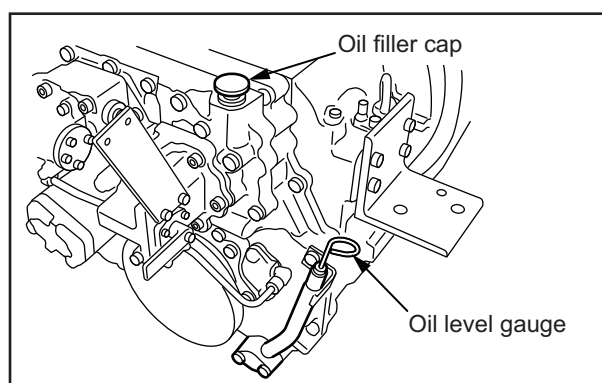


Fig. 3-21 Marine Gear Oil Filler Cap and Oil Level Gauge

Operation

Precautions in Engine Operation

Operate the Clutch Carefully

CAUTION

When shifting (operating clutch) between neutral and forward, and between neutral and reverse, make sure the engine speed is at a lower speed.

The marine clutch can be damaged if the gear (clutch) is shifted between forward and reverse while the engine is operating at high speed.

Do Not Leave the Clutch in a Half-Engaged Position

CAUTION

When shifting the marine gear clutch, be sure to securely place the clutch in the correct position, either F (Forward), R (Reverse) or N (Neutral). If the clutch lever is not firmly engaged in one of those positions, there is a risk for wearing or burning of clutch plates by slipping.

Pay Attention to Gauges and Warning Lights

CAUTION

If a gauge shows an abnormal indication or a warning light illuminates (buzzer is also activated), run the engine at idling speed, then stop the engine. After the engine stops, inspect the engine for abnormalities.

Pay Attention to Abnormal Noise

CAUTION

If the engine produces an abnormal sound during operation, stop the engine and check for the cause of noise. Continued operation may result in an unexpected accident.

Pay Attention to Exhaust Color

CAUTION

If the exhaust gas shows an abnormal color, there is a problem in the engine. Stop the engine and inspect the engine by referring to the ["TROUBLESHOOTING" \(11-1\)](#) to locate, and correct the problem.

Avoid Operating the Engine at a Speed Which Causes Resonance

CAUTION

Depending on various factors such as the ship structure, engine frame rigidly, and propeller shaft length, the engine may cause amplified vibrations. Do not operate the engine at a resonance-generating speed.

Pay Attention to Sea Water Discharging Volume

CAUTION

If sea water does not circulate properly, overheating and other problems may occur. Record the amount of sea water discharged in normal operation, and regularly check the amount of discharged sea water to judge if it is normal.

Check to see if the kingston valve, sea water strainer, etc. are clogged with dust or plastic particles.

Check to see if the sea water pump impeller is damaged.

Condensed Water Discharge

CAUTION

During operation, make sure that condensed water is drained from the intercooler condensate drain pipe.

During engine operation or immediately after stopping, condensed water will be discharged.

Discharged amount vary depending on the ambient temperature and humidity, the structure of the engine room, and the engine speed.

The engine may be damaged if condensed water is not discharged.

Limitation of Continuous Under Light Load Operation

CAUTION

Allowable minimum load during continuous operation: Operate with 30% or more of the rated output. Allowable continuous operation time with a load factor of 30% or less of the rated output: Limit the operation within one hour. Operate with a load factor of 50% or more for 30 minutes or more after continuous operation with 30% or less of the rated output is conducted.

The following problems may occur when light load operation is conducted beyond the above allowable range:

- ♦Fuel and/or oil leak from the exhaust system
- ♦Carbon build-up on the cylinder head and exhaust pipe
- ♦Sulfuric acid corrosion
- ♦Dilution
- ♦Generation of blue-white smoke (mainly during low idle operation)

Pay Attention to Unstable Engine Rotation

CAUTION

If the engine rotation becomes unstable at low idling due to engine installation and operating environment, continued operation under such conditions may cause an unexpected accident. Ensure to stabilize the engine rotation by adjusting the governor or increasing the engine rotation.

Stopping

Cautions When Stopping

CAUTION

Do not stop the engine abruptly during high-speed operation or while engine is hot. Otherwise, the engine life will be shortened. Except in a case of emergency, operate the engine in low idle for 5 to 6 minutes to cool the engine before stopping. And check the engine for abnormalities.

Do not race the engine immediately before shutdown.

Do not restart the engine immediately after abnormal stop. If the engine stops, setting off the alarm, be sure to locate the cause of the problem and correct the problem before starting the engine again. After restarting the operation, check the engine for abnormalities again. If an abnormality is found, repair it immediately.

When stopping the engine by pressing the stop button, you do not need to keep pressing the button.

Stopping Procedure

1. Place the speed control lever in the "L" (low speed) position and place the direction lever in the "N" (neutral) position.
2. Before stopping, run the engine at low idle for 5 to 6 minutes to cool the engine.
3. Press and hold the stop button until the engine completely stops.

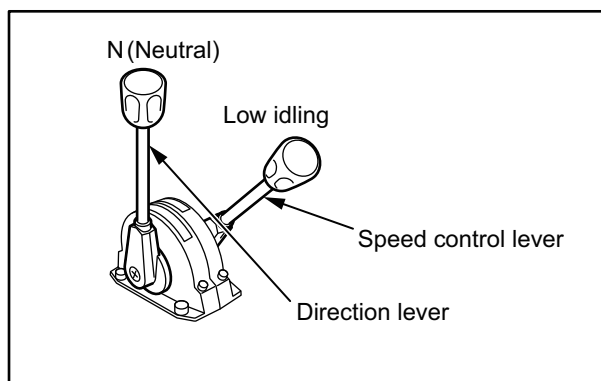


Fig. 3-22 Control Lever Stop Position

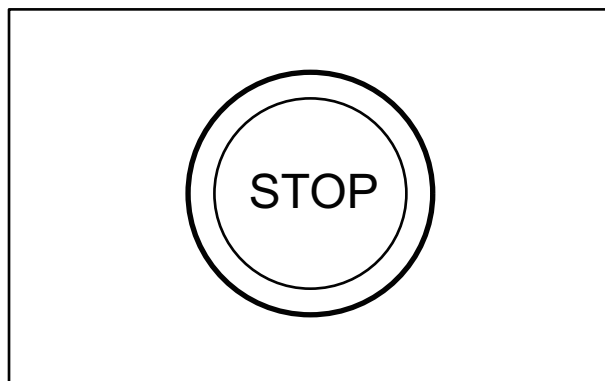


Fig. 3-23 Stop Button

4. Turn the starter switch to the "OFF" position.

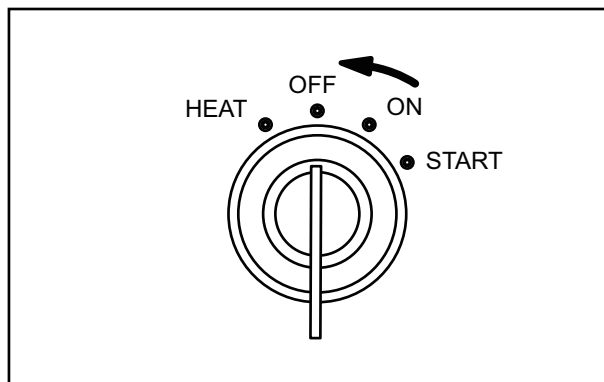


Fig. 3-24 Starter Switch "OFF"

5. Turn the battery switch to the "OFF" position.
6. Close the Kingston valve.

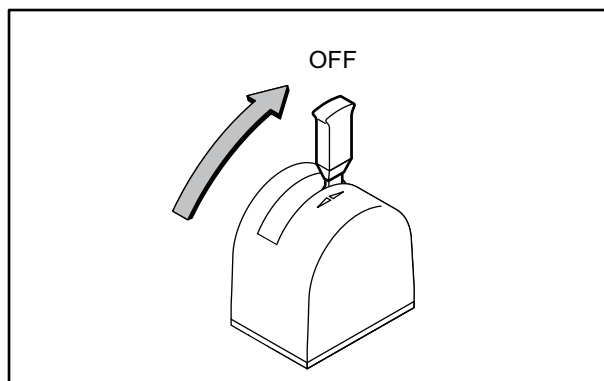


Fig. 3-25 Battery Switch "OFF"

Trolling Operation

Conditions of Use for Trolling Operation

During trolling operation, keep the engine speed below the specified speed.

Even if you perform trolling operation at high speed, the output shaft will not rotate stably.

The control range of the output shaft rotation speed during trolling operation is as shown in the table.

Table 3-3 Rotation Speed Control Range (Marine Gear MGN123GX)

Engine specified speed (min ⁻¹)	Reduction ratio	Rotation speed control range (min ⁻¹)
800	1.97	50 to 300
	2.57	50 to 280
	2.96	50 to 240

Trolling Operations



CAUTION

Be sure to conduct trolling operation once per day. If not used for extended period of time, malfunction may occur due to clogging of trolling hydraulic circuit.

After required speed is obtained by trolling operation, lock the trolling lever to prevent it from moving due to vibration.

When Trolling Device is Not Used

The trolling lever is fixed securely at the factory. Keep it as it is.

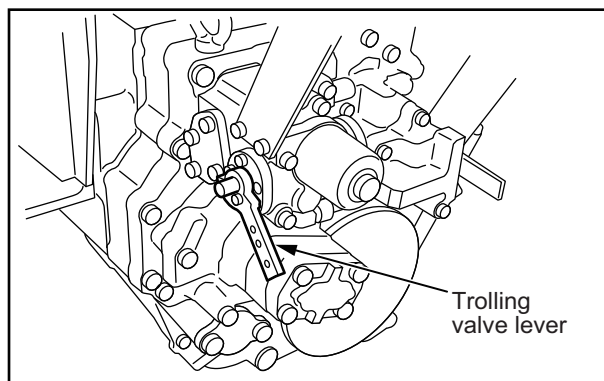


Fig. 3-26 Trolling Valve Lever

Recommended Fuel

WARNING

Use the fuel specified in this manual only. Also, do not refill the fuel tank more than the specified level. It could lead to a fire.

Use a diesel fuel that complies with the "JIS K 2204 diesel fuel."

It is necessary to use a fuel that has a pour point suitable for the ambient temperature. Choose the fuel type from the following chart.

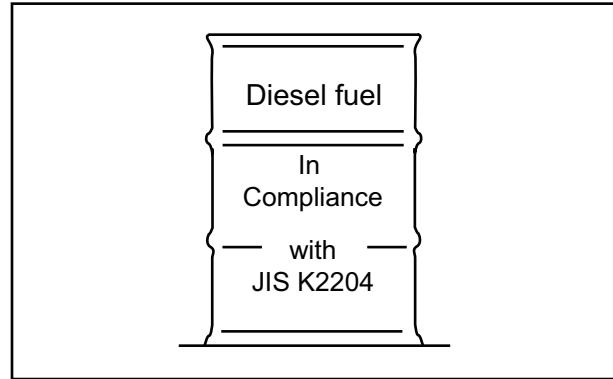


Fig. 4-1 Recommended Fuel

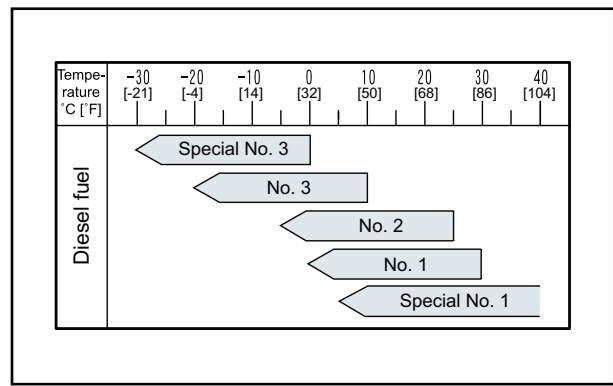


Fig. 4-2 Recommended Fuel According to Ambient Temperature

Handling Fuel

When using fuel that is stored in a storage tank, leave it for more than 24 hours to settle dust and water at the bottom, and drain them. Use the upper clean fuel.

Fill up the fuel tank or service tank at the end of each operation.

This prevents water from mixing with fuel in the tank, and also gives time for dust and water to separate and settle at the bottom of the tank.

When refilling, clean the areas around the caps of drum and tank thoroughly before removing the caps. Also clean your hands and the hose before refueling. When using a hand-operated pump, be careful not to pump water or sediment accumulated at the bottom of the storage tank.

Be sure to use a strainer when filling the fuel tank. Use clean cloth to filtrate the fuel to reduce the contaminants such as dust.

Fuel Quality Standard

Use a fuel which meets the requirements specified in the table below.

Table 4-1 Recommended Limit and Service Limit for Fuel Properties

Item		Recommended limit	Service limit	Test method
Flash point		50°C [122°F] or more (Base on fuel handling regulations.)		JIS K 2265 ISO 3679 ISO 2719
Distillation properties	Initial boiling point	170°C [338°F] or more		JIS K 2254 ISO 3405
	90% distillation temperature	330 to 380°C [626 to 716°F]		
Pour point (PP)		Lower than ambient temperature by 6°C [10.8°F] or more		JIS K 2269 ISO 3016
Cloud point (CP)		Ambient temperature or below		JIS K 2269 ISO 3015
Cold filter plugging point (CFPP)		Lower than ambient temperature by 3°C [5.4°F] or more		JIS K 2288 IP 309/96
Carbon residue (10% residual oil)		0.4 mass% or less	1.0 mass% or less	JIS K 2270 ISO 6615 ISO 10370
Cetane number		45 or more *1	45 or more *2	JIS K 2280 ISO 5165
Cetane index (new method)		45 or more		JIS K 2280 ISO/DIS 4264
Kinetic viscosity		2.0 mm ² /s or more at (30°C [86°F]) 8.0 mm ² /s or less at (50°C [122°F])		JIS K 2283 ISO 3104
Sulfur content		0.2 mass% or less	1.0 mass% or less *2 *3 (Shorten the engine oil change intervals.)	JIS K 2541 (The content amount as low as that of regular light oil is desirable) ISO 4260 ISO 8754.
Water content and sediments		0.1 volume% or less		JIS K 2275 ISO 3733
Ash content		0.01 mass% or less	0.03 mass% or less	JIS K 2272 ISO 6245
Copper corrosion (50°C [122°F], 3Hr)		Discoloration = Copper plate No. 3 or less (deep discoloration)		JIS K 2513 ISO 2160
Density 15°C [59°F]		0.83 to 0.87 g/cm ³ [51.8 to 54.3 lb/ft ³]	0.80 to 0.87 g/cm ³ [49.94 to 54.3 lb/ft ³]	JIS K 2249 ISO 3675
Coking	250°C [482°F], 24 Hr	Carbonization 75% or less	Carbonization 80% or less	Fed 791B
	230°C [446°F], 24 Hr	Carbonization 55% or less	-	
	180°C [356°F], 48 Hr	Tar-free	-	
Aromatics substances (by HPLC)		38 volume% or less (total of aroma contents)		JIS K 2536 ISO 3837
Polycyclic aromatic content		8 volume% or less		
Asphaltene		0.1 mass% or less		-
Fine foreign substances (foreign substances at fuel inlet)		10 mg/L or less		JIS B 9931 ISO 4405

Table 4-1 Recommended Limit and Service Limit for Fuel Properties

Item	Recommended limit	Service limit	Test method
Lubricity: MWSD (Measured mean Wear Scar Diameter) by HFRR wear test at 60°C [140°F] fuel temperature	460 µm [0.02 in.] or less (calculated wear scar diameter at standard vapor pressure 1.4 kPa{0.01 kgf/cm ² } [0.20 psi])	-	ISO 12156-1
BDF: Biodiesel fuel (FAME: Fatty Acid Methyl Ester)	The quality of the fuel for blending shall meet JIS K 2390, ASTM D 6751, EN14214. Mixing ratio of fuel blending: 7 volume% or less *4		JIS K 2390(FAME for blended fuel) ASTM D6751 EN 14214

*1: Cetane index (JIS K 2280) substitutes. When the fuel which satisfies the service limit of cetane number is not available with some inevitable reasons, the use of cetane booster is allowed. However, this is allowed only for the period before getting the fuel which satisfies the service limit after consulting with the fuel supplier and the manufacturer of cetane booster, and at the customer's own risk. The additive rate of 0.5% or less of cetane booster, and the lube oil analysis at every 125 hours are recommended. High concentration of additive may cause metal erosion, rubber material infiltration, increased load in high-load operation, and acceleration of lube oil deterioration.

•Brand examples of cetane number improver:

HITEC 4105K (Made by Afton Chemical)

*2: Only the emergency generator operated at an ambient temperature of 5°C [41°F] or more, a fuel of cetane number 40 to 45 and sulfur content 0.2% or less can be used, if the below requirements are satisfied:

•Install a water heater.

•Time from startup to load input is to be 40 seconds.

•Operating the engine at no load or low load (load factor 30% or less) for a prolonged period of time is avoided.

*3: If the sulfur content of using fuel is higher than 0.2 mass%, use the specified engine oil [Chapter 5 ENGINE OIL](#).

*4: In case of using BDF, consult with the fuel supplier, and consider and take necessary treatment such as;

•Antioxidation at high temperature

•Prevention from fuel solidification at low temperature

•Prevention from growth of microbe

•Removal of moisture'

For details, refer to "Technical Information".

For Engine warranty coverage, refer to "[Warranty Provisions](#)" (page - iv) conditions in this manual.

Use Recommended Engine Oil Only

CAUTION

Use the engine oil recommended in this manual only. Do not use any other oil.

The use of inappropriate or inferior oils will result in sticking of piston rings, seizure between piston and cylinder, or premature wear of bearings and moving parts, and significantly shorten the service life of the engine.

Use only MHIET genuine engine oil for the engine. If you have to use an oil other than MHIET genuine oil, check the engine oil grade, and use only the oil that meets our quality standard. Furthermore, conduct the analysis of oil to review the oil replacement intervals. MHIET disclaims the warranty claim for malfunctions due to the use of engine oil that does not meet our quality standard.

Genuine MHIET Engine Oil

MHIET have developed from the various test results to offer "MITSUBISHI DIESEL ENGINE OIL CH-4 15W-40" as the most suitable engine oil for our marine engine.

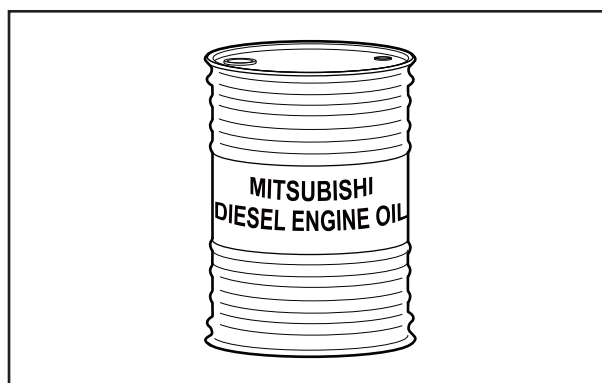


Fig. 5-1 MITSUBISHI DIESEL ENGINE OIL

Other Commercial Engine Oils

CAUTION

Never mix different brands of engine oil with genuine MHIET oil. When engine oils of different brands are mixed and used, the additives in the engine oils may chemically change and the performance of the engine oil may deteriorate. Several types of diesel engine oil are specified, but among them, use CF or CH-4 category for our engine, which is suitable for high supercharging and heavy load. When using the CF grade engine oil, the certified year must be the year of 2009 or before and the oil must meet the requirements listed in the "[Engine Oil Quality Standard](#)" (5-2). If the fuel with 0.2% or less sulfur content is used in the engine, CF or CH-4 grade oil can be used. However, the oil must have base value of 8.0 mgKOH/g or higher by Hydrochloric acid method. If measured by the perchloric acid method, the total base value must be 11.0 mgKOH/g or more.

For the engine oil quality, there are oil standards that are established through special engine tests based on the engine specifications and operating conditions. Among those standards, API (American Petroleum Institute) service classifications are mostly used to classify engine oils. The SAE standard specifies the viscosity only, while the API service classification indicates the quality level of engine oil.

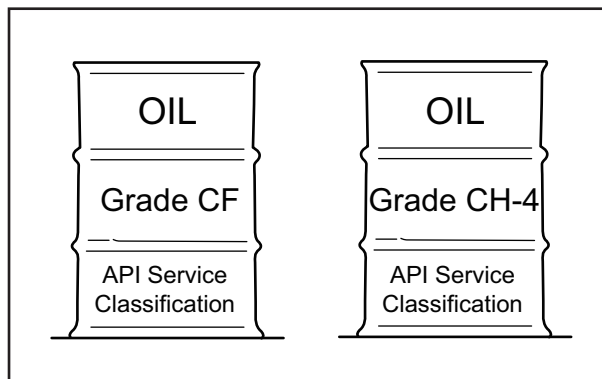


Fig. 5-2 Engine Oil Grade

Engine Oil Quality Standard

Use engine oil that meets the requirements specified in the table below:

Table 5-1 Engine Oil Quality Standards (Grade CF SAE 30)

Item				Unit	Recommended property value	Test method
ASTM Color				-	L3.0	JIS K 2580
Density		15°C [59°F]		g/cm³	0.87 to 0.90	JIS K 2249
Kinetic viscosity		40°C [104°F]		mm²/s	95.0 to 110	JIS K 2283
		100°C [212°F]			11.0 to 12.5	
Flash point				°C [°F]	200 [392] or more	JIS K 2265
Base number	Hydrochloric acid method	Sulfur content in fuel	1.0 mass% or less	mgKOH/g	10 or more (up to 13)	JIS K 2501
			0.2 mass% or less		8.0 or more (up to 13)	
	Perchloric acid method		1.0 mass% or less		13 or more (up to 16)	
			0.2 mass% or less		11 or more (up to 16)	
Acid number				mgKOH/g	1.8 or less	JIS K 2501
Sulfur content				%	0.7 or less	JIS K 2541
Sulfuric acid ash				mass%	2.0 or less	JIS K 2272
Carbon residue content				%	2.0 or less	JIS K 2270
High temperature shear viscosity		150°C [302°F]		mPa·S	2.9 or more	JPI-5S-36-91
Pour point				°C [°F]	-12.5 [9.5] or less	JIS K 2269
Additives		Ca		mass%	0.40 to 0.48	JIS K 0116
		P			0.037 to 0.050	
		Zn			0.042 to 0.055	
		B			0.010 or less	
		Si			0.005 or less	
		N		0.060 or less	JIS K 2609	
Bubbling test		I		mL	10/0 or less	JIS K 2518
		II			30/0 or less	
		III			10/0 or less	
Panel coking test*		300°C [572°F]		-	40 or less	FED791-3462
		325°C [617°F]			300 or less	

*: Temperature of aluminum panel: 300°C [572°F] and 325°C [617°F], Temperature of engine oil: 100°C [212°F], Splatter time: 15 seconds, Downtime: 45 seconds, Test time: 8 hours. The properties are the weight of solid product accumulated on the panel.

Table 5-2 Engine Oil Quality Standards (Grade CF SAE 15W-40)

Item				Unit	Recommended property value	Test method
ASTM Color				-	L4.0	JIS K 2580
Density		15°C [59°F]		g/cm³	0.87 to 0.90	JIS K 2249
Kinetic viscosity		40°C [104°F]		mm²/s	100 to 110	JIS K 2283
		100°C [212°F]			13.5 to 15.5	
Flash point				°C [°F]	225 to 250 [437 to 482]	JIS K 2265
Base number	Hydrochloric acid method	Sulfur content in fuel	1.0 mass% or less	mgKOH/g	10 or more (up to 13)	JIS K 2501
			0.2 mass% or less		8.0 or more (up to 13)	
	Perchloric acid method		1.0 mass% or less		13 or more (up to 16)	
			0.2 mass% or less		11 or more (up to 16)	
Acid number				mgKOH/g	15 to 2.0	JIS K 2501
Sulfur content				%	0.5 or less	JIS K 2541
Sulfuric acid ash				mass%	2.0 or less	JIS K 2272
Carbon residue content				%	2.0 or less	JIS K 2270
High temperature shear viscosity		150°C [302°F]		mPa·S	3.7 or more	JPI-5S-36-91
Pour point				°C [°F]	-25 [-13] or less	JIS K 2269
Additives		Ca		mass%	0.480 to 0.570	JIS K 0116
		P			0.050 to 0.070	
		Zn			0.060 to 0.080	
		B			0.010 or less	
		Si			0.001 or less	
		N		0.030 to 0.060	JIS K 2609	
Bubbling test		I		mL	10/0 or less	JIS K 2518
		II			30/0 or less	
		III			10/0 or less	
Panel coking test*		300°C [572°F]		-	140 or less	FED791-3462
		325°C [617°F]			300 or less	

*: Temperature of aluminum panel: 300°C [572°F] and 325°C [617°F], Temperature of engine oil: 100°C [212°F], Splatter time: 15 seconds, Downtime: 45 seconds, Test time: 8 hours. The properties are the weight of solid product accumulated on the panel.

Table 5-3 Engine Oil Quality Standards (Grade CH-4 SAE 15W-40)

Item		Unit	Recommended property value	Test method
ASTM Color		-	L4.0	ASTM D 1500
Flash point		°C [°F]	200 [392] or more	ASTM D 92
Kinetic viscosity	40°C [104°F]	mm ² /s	100 to 120	ASTM D 445 ASTM D 7042
	100°C [212°F]		13.00 to 15.00	
CCS Viscosity	-20°C [-4°F]	mPa·S	7000 or less	ASTM D 5293
MRV Viscosity	-25°C [-13°F]	mPa·S	60000 or less	ASTM D 4684
Sulfuric acid ash		mass%	2.0 or less	ASTM D 874
Acid number		mgKOH/g	4.0 or less	ASTM D 664
Base number	Hydrochloric acid method	mgKOH/g	8.0 or more	ASTM D 2896
	Perchloric acid method	mgKOH/g	11 or more	
Pour point		°C [°F]	-25 [-13] or less	ASTM D 7346 ASTM D 6749/97
Bubbling test	I	mL	10/0 or less	ASTM D 892
	II		20/0 or less	
	III		10/0 or less	
Additives	Ca	mass%	0.38 to 0.48	ASTM D 5185 ASTM D 4951 ASTM D 6481
	P		0.11 to 0.15	
	Zn		0.12 to 0.17	
	S		0.5 or less	
NOACK (evaporability)		mass%	18 or less	ASTM D 5800
High temperature shear viscosity	150°C [302°F]	mPa·S	3.7 or more	ASTM D 4741
Carbon residue content		-	2.0 or less	
Hot tube test *		-	4.0 or more	

*300°C [572°F], 16 hours

Selection of Oil Viscosity

Use the chart on the right to select the appropriate oil viscosity according to the ambient temperature.

Excessively high oil viscosity causes power loss and an abnormal rise of oil temperature, while excessively low oil viscosity accelerates wear and causes gas leak from the cylinder due to inadequate lubrication, and also causes a decrease in engine output.

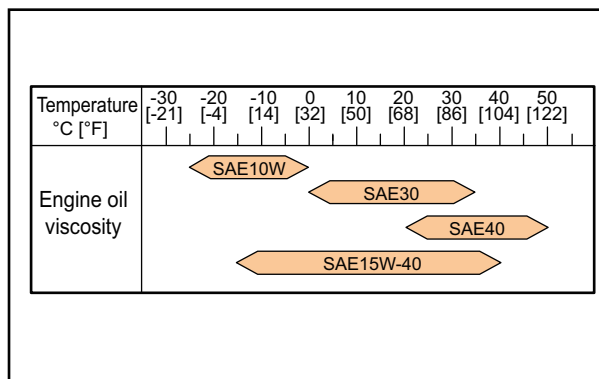


Fig. 5-3 Selection of Oil Viscosity

Handling Engine Oil



WARNING

Before filling the engine with engine oil, stop the engine and make sure there is no open flame nearby. If oil is spilled or leaked on hot surfaces or electrical components, it may cause a fire. Wipe off any spilled oil immediately and thoroughly. After filling oil, securely close the filler cap.

When handling a large amount of engine oil more than the legally specified quantities, be sure to perform the work in a service station operated under the provision of the law. When draining oil from the engine or oil can, be sure to use an oil pump.

Tighten the oil can cap securely.

Store the oil can in a well-ventilated place and out of direct sunlight.

Be sure to obtain the SDS of the engine oil and follow the instructions in the SDS.

Marine Gear Oil

CAUTION

For marine gear oil, use SAE 30 single grade oil. Do not use multi-grade oil.

The use of multi-grade oil results in harmful effect on marine gears.

The marine gear oil serves as lubricant as well as clutch hydraulic oil. Use the oil that has high stability against temperature changes, acid resistance, and excellent water resistance. Also the oil must have no harmful effect on the materials of gears and clutch plates.

Use SAE 30 single grade oil as marine gear oil. Do not use multi-grade oil. The additive contained in the multi-grade oil reduces friction characteristics of the clutch plate.

Tighten the cap of marine gear oil can firmly.

Store the oil can in a well-ventilated place and out of direct sunlight.

Be sure to obtain the SDS (Safety Data Sheet) of the marine gear oil and follow the instructions of the SDS.

Service Limits for Engine Oil

Engine oil degrades through the use and by the lapse of time. The quality of engine oil and the operating condition of the engine have influence on deterioration of the engine oil. Change the engine oil in accordance with [Chapter 7 PERIODIC MAINTENANCE SCHEDULE](#). However, only when the engine oil analysis result allows, the oil change intervals can be extended. The limit of extended oil change interval is 500 hours. For the determination of engine oil properties degradation, see the table below. If any of oil properties exceeds the limit, change the engine oil with new oil.

Table 5-4 Engine Oil Properties

Properties		Standard value		Test standard
Kinetic viscosity	mm ² /s @100°C [212°F]	For main engine/ main generator	+30% or less rate of change from new oil 10 mm ² /s or more	JIS K 2283 ISO 3107 ISO 2909
		For emergency generator	+30% or less rate of change from new oil -20% or more rate of change from new oil	
Base number	mgKOH/g	2.0 or more with hydrochloric acid (HCL) method 1/2 of new oil or more by perchloric acid (PCA) method		JIS K 2501 ISO 3771
Acid number	mgKOH/g	+3.0 or less of new oil		JIS K 2501 ISO 3771
Water content	volume%	0.2 or less		JIS K 2275 ISO 9029
Flash point (open cup)	°C [°F]	180 [356] or more		JIS K 2265 ISO 3679 ISO 2719
Pentane insolubles	mass%	0.5 or less		ASTM D 893
Coagulated pentane insolubles	mass%	3.0 or less		ASTM D 893

Definition of Property Limit of Engine Oil

Kinetic Viscosity

Kinetic viscosity is a basic physical property of engine oil and is considered as the most important factor when evaluating oil.

The kinetic viscosity increases by contamination with blow-by gas and degradation of oil. Also, the viscosity decreases by contamination with fuel and molecular disconnection of the viscosity index improver. The former will cause oil filter clogging and sludge accumulation in the engine, while the latter will cause poor lubrication and wear.

Base Number

The total base number represents the ability to neutralize organic acids generated by the oxidation of engine oil and sulfurous acid and sulfuric acid by burning sulfur compounds in fuel. Because the base number indicates the amount of dispersant detergent in oil, it can be used to estimate the consumption of basic dispersant detergent. The ability to disperse sludge declines as the dispersant detergent is consumed. Thus, the base number is often used as an indication of cleaning capability decline.

Acid Number

The total acid number in the oil increases due to the formation of organic acids by the oxidation of engine oil, the formation of sulfurous acid and sulfuric acid by the combustion of sulfur compounds in the fuel, and the incomplete combustion products.

An increase in the acid number will result in corrosion or wear of the inner parts of the engine (such as cylinder liner and bearing) due to sulfur content, and the piston ring seizure due to sludge.

Water Content

Water in oil promotes corrosion/wear, and decreases lubricity between sliding parts.

Flash Point

The flash point is lowered by contamination with fuel. Flash point is used to check the fuel dilution of oil. The dilution of oil reduces oil film, and causes insufficient lubrication that will cause friction or wear of engine parts.

Insolubles

Insolubles include acid products of engine oil, imperfect combustion products, sludge or soot, worn metal particles and dust. Insolubles value is an indication of degradation/contamination of oil.

Dispersant detergent, which is an additive in engine oil, absorbs sludge particles, and disperses them as fine particles in oil. Total insoluble density and remaining dispersibility can be obtained by measuring insoluble and coagulated insoluble (chemical specialties which stop action of dispersant detergent and collect the sludge dispersed in oil) to identify the engine oil contamination level, and thereby, the insoluble value can be a marker to prevent the piston ring from seizure or premature wear.

Engine Oil Analysis Service

For a long productive service life of engine, the use of engine oil analysis service is recommended.

By this service, the engine oil, extracted from the engine with a dedicated sampling tool, is analyzed to determine whether the oil being used is acceptable or not for the use.

The following information is obtained by the engine oil analysis service:

- ♦The amount of fine metal powder in engine oil due to abrasion is measured, by which, worn parts of the engine can be located.
- ♦Water, LLC, or salt that should not be in engine oil can be detected if presented.
- ♦Deteriorated condition of engine oil is shown. These will allow the planning of operational and maintenance counter-measures, and show the proper engine oil replacement intervals.

The engine oil analysis service can diagnose the internal condition of the engine without disassembling the engine.

It is highly recommended to take advantage of our engine oil analysis service so that you can find the engine condition before any malfunction occurs in the engine.

In this operation manual, the word "coolant" signifies a mixture of water and LLC.

Recommended Water for Coolant

Use soft water (such as tap water) for the engine cooling system. The water quality must meet the requirements in the table below. Basically, the water quality should be within the range of the recommended values, however, up to the limit value is acceptable.

Table 6-1 Water Quality Standard

Item	Chemical symbol	Unit	Recommend value	Limit value	Main harm
pH (25°C [77°F])	-	-	6.5 to 8.0	6.5 to 8.5	Corrosion and scale formation
Electrical conductivity (25°C [77°F])	-	mS/m	≤ 25	≤ 40	Corrosion and scale formation
Total hardness	CaCO ₃	mg/L	≤ 95	≤ 100	Scale formation
M alkalinity	CaCO ₃	mg/L	≤ 70	≤ 150	Scale formation
Chlorine ion	Cl ⁻	mg/L	≤ 100	≤ 100	Corrosion
Sulphate ion	SO ₄ ²⁻	mg/L	≤ 50	≤ 100	Corrosion
Total iron	Fe	mg/L	≤ 1.0	≤ 1.0	Scale formation
Silica	SiO ₂	mg/L	≤ 30	≤ 50	Scale formation
Residue by evaporation	-	mg/L	≤ 250	≤ 400	Scale formation

Long Life Coolant (LLC)

CAUTION

If you swallow coolant or LLC accidentally, induce vomiting immediately and seek medical attention. If LLC gets in your eyes, flush immediately with plenty of water and seek medical attention.

Be sure to use MHIET genuine long life coolant (LLC), "GLASSY long life coolant (ethylene glycol type)" or "PG GLASSY long life coolant (propylene glycol type)." When using an LLC other than genuine MHIET long life coolant by necessity, be sure to use the non-amine type LLC that meets our requirements. MHIET disclaims the warranty claim for defects due to the use of LLC that does not meet our requirements.

Genuine MHIET LLC

MHIET recommends the use of our genuine long life coolant "GLASSY long life coolant (ethylene glycol type)" and eco-friendly product "PG GLASSY long life coolant (propylene glycol type)," which are most appropriate coolant for Mitsubishi diesel engines.

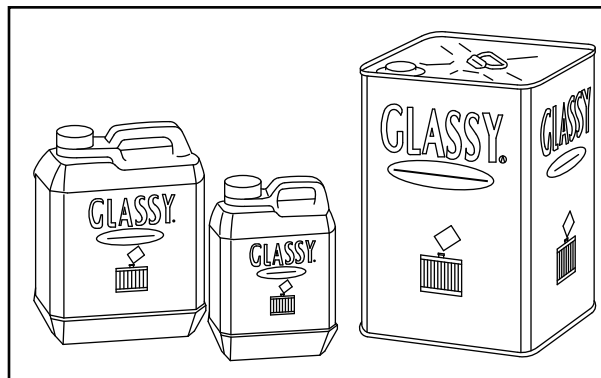


Fig. 6-1 GLASSY Long Life Coolant

Other Commercial LLCs

CAUTION

Never mix genuine MHIET LLC with other brand of LLCs. Mixing with other brand of LLCs degrades the performance of genuine MHIET LLC.

When using an LLC other than genuine MHIET long life coolant (LLC) "GLASSY long life coolant (ethylene glycol type)" or "PG GLASSY long life coolant (propylene glycol type)", be sure to use the LLC that meets our requirements.

The quality and performance of commercially available LLCs and their component variations are the responsibility of LLC suppliers.

Before purchasing a commercial LLC, be sure to discuss the suitability of LLC with the LLC supplier.

Use an all-season LLC (non-amine type) only. Do not use antifreeze alone instead of LLC.

Requirements for Other Commercial LLCs

If you must use other brand of LLCs, be sure to use the LLC that meets the requirements below. MHIET disclaims the warranty claim for defects caused by the use of LLC that does not meet our requirements.

General Quality Requirements for LLC

- LLC must be a homogeneous liquid without sediment.
- When the LLC is diluted to 30 to 60% density, the LLC must not cause any problems such as corrosion and precipitation deposits in the engine cooling system.
- LLC must be mixed well with other non-amine type LLC that meets this requirements and must not separate elements included in the each product, and must not decrease the performance of both products.
- LLC must not corrode the container and must not produce a precipitate when LLC is stored in the container for 6 months.
- LLC must be free from any abnormalities such as precipitates when kept in -20 to -25°C [-4 to -13°F] temperature.
- The validity period for the quality requirements for products specified herein must be 2 years after the delivery, provided that they are stored under indoor normal temperature.

LLC Quality Standard

LLC must be tested in accordance with JIS K 2234, Section 7 "Test method," and satisfy the requirements. General matters and specimen sampling method must comply with JIS K 2234.

Table 6-2 LLC Quality Standard

Test items				Standard value
Visual inspection				No precipitation
Specific gravity				Minimum 1.112 g/cm ³ [69.4199 lb/ft ³] (20/20°C) [20/68°F] (undiluted solution)
Water content				5.0 weight or less (undiluted solution)
Freezing temperature	30% by volume in aqueous solutions			-14.5°C [5.9°F] or less
	50% by volume in aqueous solutions			-34.0°C [-29.2°F] or less
Equilibrium reflex boiling point				155°C [311°F] or more (undiluted solution)
pH				7.0 to 11.0 (30% by volume in aqueous solution)
Bubbling character (ASTM D3306-01)	30% by volume in aqueous solutions			4.0 mL [0.0008 gal] or less
	33 ¹ / ₃ % by volume in aqueous solutions			150 mL [0.032 gal] or less, deforming time 5 sec. or less
Hard water compatibility				1.0 or less (50% by volume in aqueous solution)
Metallic causticity (88±2°C [190.4±4°F], 336±2 Hrs, 30% by volume in aqueous solution (ethylene glycol), 50% by volume in aqueous solution (propylene glycol))	Metallic test piece	Mass change	Aluminum	±0.30 mg/cm ²
			Cast iron	±0.15 mg/cm ²
			Steel	±0.15 mg/cm ²
			Brass	±0.15 mg/cm ²
			Solder	±0.30 mg/cm ²
			Copper	±0.15 mg/cm ²
		Visual inspection of test piece after testing		Any corrosion should not be observed except for the contacting position of the test piece and spacer. Discoloration is allowed.
	Bubble formation during test			Bubble must not overflow.
	Property of liquid after test	pH		6.5 to 11.0
		pH change		±1.0
		Precipitation		0.5% by volume in aqueous solution or less
		Visual inspection of liquid		No significant discoloration. No signifi- cant changes such as separation and gel generation.

Table 6-2 LLC Quality Standard

Test items				Standard value
Circulating corrosion (98±2°C [208.4±4°F], 1000 Hrs, 30% by volume in aqueous solution (ethylene glycol), 50% by volume in aqueous solution (propylene glycol))	Metallic test piece	Mass change	Aluminum, cast iron, steel, brass, solder, and copper	±0.30 mg/cm ²
		Visual inspection of test piece after testing		Any corrosion should not be observed except for the contacting position of the test piece and spacer. Discoloration is allowed.
	Property of liquid after test	pH		7.0 to 9.0
		pH change		±1.0
		Reserve alkalinity change		±15%
		Precipitation		1.0% by volume in aqueous solutions or less
		Visual inspection of liquid		No significant discoloration. No significant changes such as separation and gel generation.
		Ion concentration	Iron, copper, aluminum, zinc, lead, and ammonium ion	10 ppm or less
Circulating corrosion (88±3°C [190.4±6°F], 1000±2 Hrs, 30% by volume in aqueous solution (ethylene glycol))	Metallic test piece	Mass change	Aluminum	±0.60 mg/cm ²
			Cast iron	±0.30 mg/cm ²
			Steel	±0.30 mg/cm ²
			Brass	±0.30 mg/cm ²
			Solder	±0.60 mg/cm ²
			Copper	±0.30 mg/cm ²
		Visual inspection of test piece after testing		Any corrosion must not be observed except for the contacting position of the test piece and spacer. Discoloration is allowed.
	Property of liquid after test	pH		6.5 to 11.0
		pH change		±1.0 or less
		Visual inspection of liquid		No significant discoloration. No significant changes such as separation and gel generation.
	Condition of parts	Pump seals		Free from any malfunction, liquid leak, and abnormal noise during operation.
		Pump case inner surfaces and blades		Free from significant corrosion.

Table 6-2 LLC Quality Standard

Test items			Standard value
Rubber adaptability (30% by volume in aqueous solution, 115°C [239°F], 360 Hrs)	Silicone	Tensile strength change rate	-60 to 0%
		Elongation change rate	-40 to +20%
		Volume change rate	0 to +40%
		Hardness change rate	-20 to +10%
	Nitrile rubber	Tensile strength change rate	0 to +10%
		Elongation change rate	-15 to +15%
		Volume change rate	0 to +40%
		Hardness change rate	-10 to 0%
	Ethylene pro- pylene diene monomer	Tensile strength change rate	0 to +10%
		Elongation change rate	-30 to 0%
		Volume change rate	0 to +10%
		Hardness change rate	-10 to 0%
Storage stability (% by volume in aqueous solution) (30% by volume in aqueous solutions, room temperature 6 Hrs)			0.3 or less

Maintenance of LLC

CAUTION

If you swallow coolant or LLC accidentally, induce vomiting immediately and seek medical attention. If LLC gets in your eyes, flush immediately with plenty of water and seek medical attention.

LLC is toxic. Do not dump coolant containing LLC drained from the engine casually into sewage. For disposal of used coolant, consult the LLC distributor.

Replacement Intervals of LLC

CAUTION

Be sure to renew LLC (coolant) at the intervals specified in the "Periodic Maintenance Schedule".

Failure to replace LLC may cause malfunctions due to rust prevention performance degradation and cavitations.

LLC Concentration (GLASSY and PG GLASSY)

- To prevent cavitations of water pump and cylinder liners, LLC concentration must be at least 30% for GLASSY (ethylene glycol) and 40% for PG GLASSY (propylene glycol) by volume under any temperature conditions throughout the year.
- Coolant anti-freeze concentration for the engine is determined by the ambient minimum temperature of the year. Maintain the coolant concentration in the range shown in the table below:

Table 6-3 Recommended LLC Concentration

Ambient temperature		Up to -10°C [14°F]	Up to -20°C [-4°F]	Up to -30°C [-22°F]	Up to -45°C [-49°F]
LLC concentration	GLASSY (ethylene glycol)	30%	40%	50%	60%
	PG GLASSY (propylene glycol)	40%	55%	70%	90%

- Concentration must be 60% at a maximum for GLASSY (ethylene glycol) and 90% for PG GLASSY (propylene glycol). If the concentration is higher than that, the antifreeze effect will decrease, or the cooling water temperature will increase due to the lowered specific heat.
- Coolant temperature will increase by approximately 1.5°C [2.7°F] for 60% concentration of GLASSY (ethylene glycol) and approximately 3°C [5.4°F] for 90% concentration of PG GLASSY (propylene glycol). Check heat exchanger capacity of the cooling system to avoid overheating.

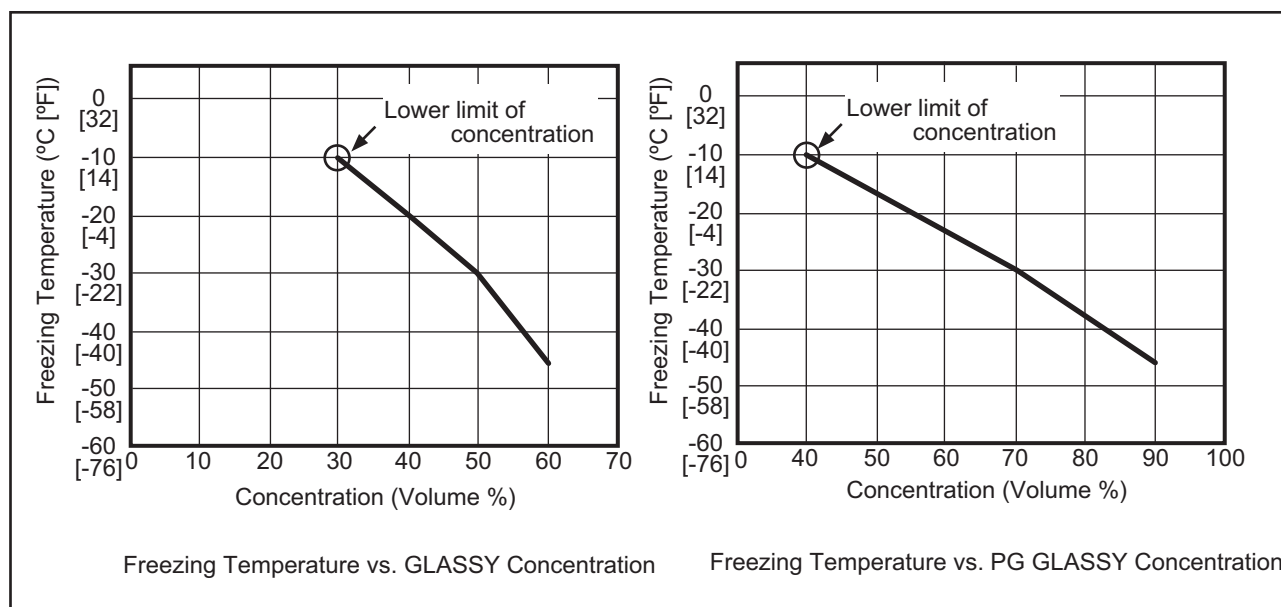


Fig. 6-2 Coolant Freezing Temperature (GLASSY and PG GLASSY)

LLC Concentration Measuring Method

Tool

Coolant tester

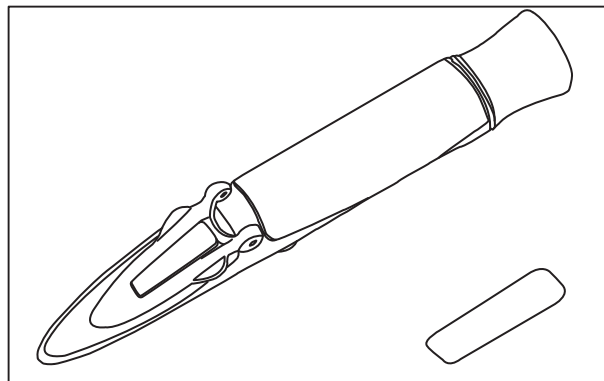


Fig. 6-3 Coolant Tester

Calibration

1. Place one or two drops of distilled or tap water on the prism.

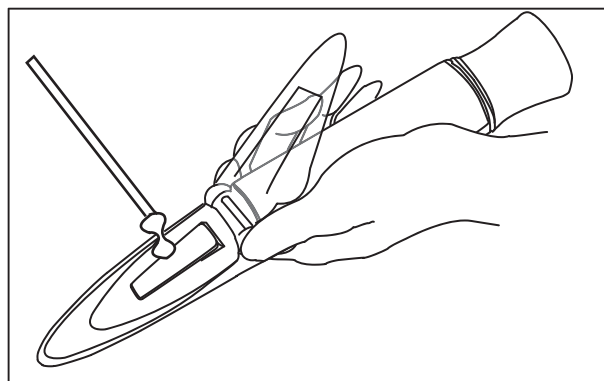


Fig. 6-4 Measuring Procedure 1

2. Close the daylight plate gently.

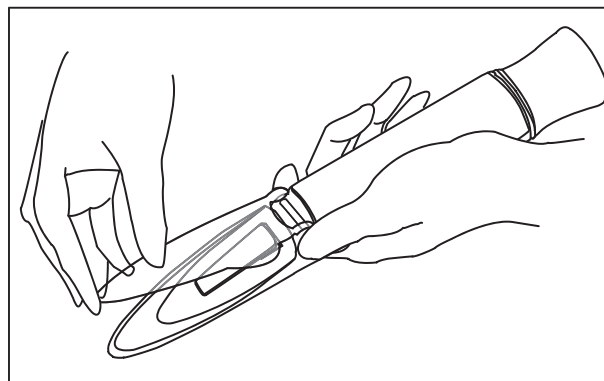


Fig. 6-5 Measuring Procedure 2

3. Spread the drop evenly on the prism surface. Do not allow bubbles staying on the surface.

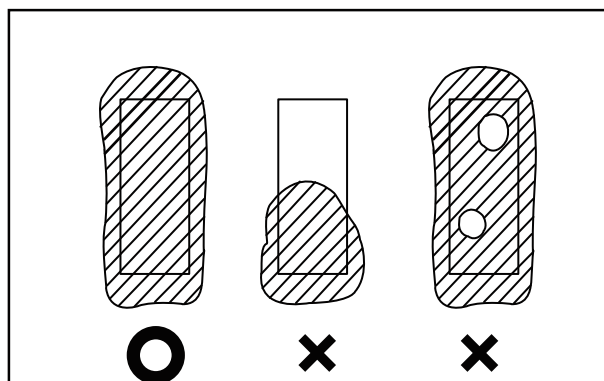


Fig. 6-6 Measuring Procedure 3

4. Read the scale through the eye piece. Turn the eye piece until the scale is clearly visible.

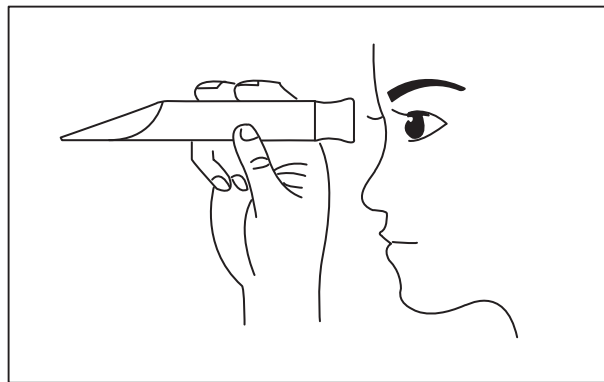


Fig. 6-7 Measuring Procedure 4

5. Verify the boundary line of blue color aligns with the 0% on the scale.

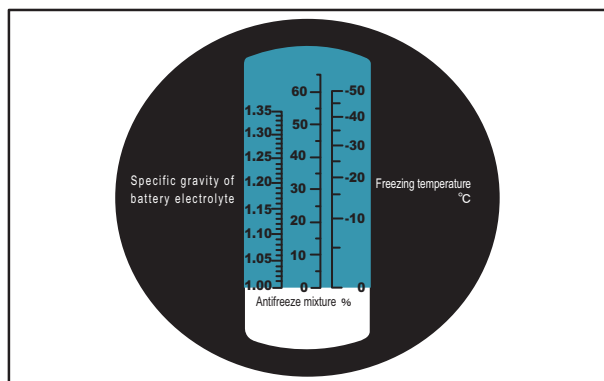


Fig. 6-8 Measuring Procedure 5

6. Adjust the scale calibration screw with the tool to align the boundary line and the 0% line if they are not aligned.

CAUTION

Do not rotate the calibration screw excessively. The refractometer may be damaged.

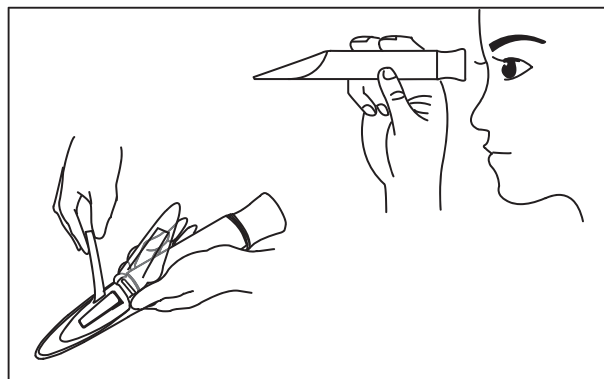


Fig. 6-9 Measuring Procedure 6

Measurement

1. Place one or two drops of specimen on the prism.
(Fig. 6-4)
2. Close the daylight plate gently. (Fig. 6-5)
3. Spread the specimen evenly on the prism surface.
Do not allow bubbles staying on the surface.
(Fig. 6-6)
4. Read the scale through the eye piece. Turn the eye piece until the scale is clearly visible. (Fig. 6-7)
5. Read the measured value where the boundary line crosses the scale line.

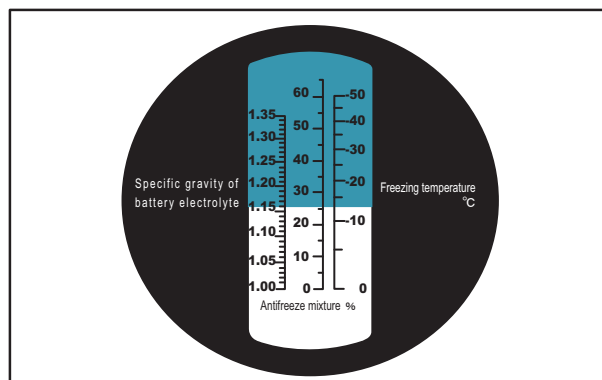


Fig. 6-10 Measuring Procedure 7

6. Wipe off the specimen with water-soaked soft facial tissue.

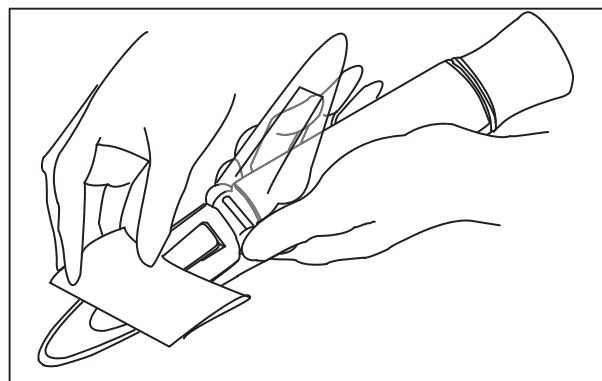


Fig. 6-11 Measuring Procedure 8

Necessity of LLC

Smaller and lighter engines are today's trend as they can offer greater output, lower fuel consumption, and lower exhaust emission levels.

Conditions to which engine coolant is subjected, therefore, are becoming severer due to longer operating hours, higher coolant temperature, and higher coolant circulating speed.

Furthermore, many different materials such as steel, aluminum, copper, solder, and rubber are used in the cooling system, and they are also subject to the severe conditions described above. Those materials have different ionization characteristics, and this difference accelerates corrosion through the medium of engine coolant. To prevent such a problem, it is necessary to use the LLC containing additives that prevent rust.

Characteristics of LLC Additives

LLC contains several chemicals in such proportions as to produce chemical reactions that suppress corrosion (ionization) of engine parts that contact with the coolant. LLC loses its effectiveness by hours of use as well as lapse of time.

Furthermore, if the chemicals are not well proportioned to match the metals used in the cooling system, certain chemicals in the LLC become rapidly used up, and it results in corrosion of metals to be protected. Consequently, other corrosion preventing chemicals react with dissolving metals, by which corrosion is accelerated. This condition generates more severe corrosion than when plain soft water is used. This is a typical problem caused by the use of inappropriate LLC.

Examples of Abnormalities Caused by Amine Type LLC

Pitting of Iron Parts

Amines are generally effective in suppressing the rusting of ferrous metals, but they are said to become corrosion promoter for copper parts.

Dissolved copper (copper corrosion) in the cooling system deposits on iron parts, and the copper deposits will cause corrosion and then pitting on iron parts that have a high ionization characteristics due to galvanic or local-cell action.

Corrosion of Aluminum Parts

Silicate is highly effective in protecting aluminum against rusting. However, it is unstable in a solution in which the pH is 9 or lower, and can turn to gel and precipitate in the solution. For this reason, the pH is usually specified to be about 10 to ensure a high alkaline level.

This means, after silicate is used up, the high alkalinity causes chemical attacks on aluminum. To prevent this problem, proper maintenance of the coolant is required. For example, rapid wear of water pump mechanical seal due to gelification of silicate salt has been observed.

Pitting and Clogging of Heat Exchanger

When LLC deteriorates or when its concentration in the coolant becomes low, the anti-corrosion performance of LLC lowers and results in the corrosion of metals. Brass and solder tend to corrode faster than other metals, and corrosion of these metals is said to cause water leakage and clogs. Example: Holes and clogs in heat exchanger.

Chapter 7 PERIODIC MAINTENANCE SCHEDULE

How to Use the Periodic Maintenance Schedule

Scheduled maintenance not only extends the service life of the engine but also serves to ensure the safe operation. Be sure to conduct the inspection and maintenance according to the "Periodic Maintenance Schedule".

Obey the standard service intervals specified in the "Periodic Maintenance Schedule". However, when you think the engine should need the inspection and maintenance earlier than the specified intervals in the "Periodic Maintenance Schedule", change the intervals accordingly.

Note: Appropriate service intervals vary with usage and operating conditions as well as conditions of fuel, oil, and coolant.

Be sure to check the items which are included in the applicable interval and shorter intervals. Be sure to conduct periodic inspection at specified intervals, either hours or calendar days, whichever comes first.

(Example) During the inspection conducted at "Every 4000 Service Hours," also inspect the items listed under "Every 2000 Service Hours" and "Every 1000 Service Hours."

Items marked with * in the "Periodic Maintenance Schedule" require special tools or large-scale maintenance. For those items, contact your MHIET dealer.

<Engine top overhaul>

On the top overhaul, remove the cylinder head, inspect and replace as required the cylinder head, combustion chamber and other main components. For details of top overhaul, contact your MHIET dealer.

<Engine major overhaul>

On the major overhaul, disassemble the whole engine, conduct inspection, maintenance, and replacement of main components.

For details of major overhaul, contact your MHIET dealer.

Table 7-1 Rating Definition for Diesel Engine for Marine Propulsion Application

Symbol			L (P)
Power ratio (New)			1.0
Name of rating			L-rating (P) (Light Duty)
Over load operation			Not possible
Required conditions for warranty *1	Load/ operating hour *2	Allowable ave. load factor/yr	75% or lower
		Allowable ave. speed *4	91% or lower
		Allowable continuous operation with over 100% load	Up to 2 Hr per 24 Hr
	Overhaul interval after delivery <Maximum> *3	Top	4000 Hr
		Major	8000 Hr or 3yr whichever comes earlier
	Operating Hr/year		-
Operating Hr/year (Typical)			2000 Hr or lower
Typical Application			Pleasure boats, Yachts, Patrol boats, Fire fighting boats

*1 This condition constitutes a part of required conditions for warranty that Mitsubishi Heavy Industries Engine & Turbocharger, Ltd. agrees with the other party under Diesel Engine Sales Contract with the party (hereinafter "Individual Contract") however details of the warranty descriptions and the conditions shall be referred to the individual Contract.

Atmospheric condition as per ISO 15550: 2002 (JIS B 8003: 2005) (Barometric pressure:100 kPa {1.02 kgf/cm²} [14.5 psi], ambient temperature:298 K, relative humidity:30%).

*2 Average load factor (per day or year) shall be calculated as per the formula in ISO 8528-1:2018 'average power output (Ppp)'.

*3 Refer to Operation Manual for more information regarding inspection and maintenance including items and descriptions.

*4 This applies to fixed-pitch propellers. For CPP, allowable average load factor shall be as per the required conditions for warranty of the average load factor.

*This document may be changed without prior notification.

Periodic Maintenance Schedule

Table 7-2 Periodic Maintenance Schedule

Service Intervals	Service Items	Page
Initial 100 hours (Only once)	Engine Oil, Oil Filter, and Bypass Oil Filter - Replace	8-9
	Replace marine gear oil and clean marine gear oil strainer Replace marine gear governor oil filter	8-13
	Fuel Filter - Replace	8-7
	Valve Clearance - Inspect and Adjust	*
	Engine Externals - Inspect	3-9
Every 250 hours	Engine Oil, Oil Filter, and Bypass Oil Filter - Replace	8-9
	Belt and Belt Tension - Inspect and Adjust	8-2
	Pre-cleaner - Clean, Inspect, and Replace	8-21
Every 500 hours	including items listed in every 100 and 250 hours	-
	Zinc Rod - Replace	8-19
	Gauze Filter - Clean	8-6
Every 1000 hours	including items listed in every 100, 250, and 500 hours	-
	Fuel Filter - Replace	8-7
	Replace marine gear oil and clean marine gear oil strainer Replace marine gear governor oil filter	8-13
	Sea Water Pump Impeller - Inspect	8-19
	Fresh Water Pump - Lubricate	8-17
	Turbocharger Rotor - Inspect for Movement and Looseness	*
	Valve Clearance - Inspect and Adjust	*
	Fuel Injection Nozzle - Inspect and Adjust	*
Every 2000 hours or every 1 years	including items listed in every 100, 250, 500, and 1000 hours	-
	High Pressure Fuel Injection Pipe and Clamp Seat - Visually Inspect	8-8
	Low Pressure Fuel Pipe, and Oil Pipe - Visually Inspect	8-8
	Fuel Injection Nozzle Tip, Nozzle Spring and Spacer - Replace (After the replacement, inspect and adjust the spray/injection pressure)	*
	Sea Water Pump Impeller - Replace	*
	Bolts and Nuts on Exhaust and Air Inlet Pipes - Tighten	*
	Harnesses and Terminals - Inspect for Damage and Looseness	*

Table 7-2 Periodic Maintenance Schedule

Service Intervals	Service Items		Page
Every 4000 hours or every 2.5 years	including items listed in every 100, 250, 500, 1000 and 2000 hours		-
	Engine Overhaul	Cylinder Head - Disassemble and Inspect Valve Mechanism - Inspect Cylinder Liner Inside Surface - Inspect	*
	Belt - Replace		*
	Damper - Inspect		*
	Fuel Injection Timing - Inspect and Adjust		*
	Heat Exchanger - Clean		*
	Thermostat Operation - Check		*
	Starter - Inspect		*
	Alternator - Inspect		*
	Protective Devices - Check Actuation		*
	Coolant (Fresh Water) - Change (Every 2 Years)		8-15
Every 8000 hours or every 5 years	including items listed in 100, 250, 500, 1000, 2000, and 4000 hours		-
	Engine Overhaul	Piston - Check Piston Cooling Nozzle - Inspect Crankshaft - Inspect Main Bearing - Replace Thrust Plate - Replace Connecting Rod Bearing - Replace Camshaft Bushing - Inspect Cylinder Liner - Replace Piston Ring - Replace Inlet and Exhaust Valves - Replace Inlet and Exhaust Valve Seat Rings - Replace Valve Rotator - Replace	*
	Fuel Flexible Hose - Replace		*
	Fuel Injection Pump - Inspect and Test (Replace Parts as Needed.)		*
	Governor - Inspect and Test (Replace Parts as Needed.)		*
	Clamp Seat for High-Pressure Fuel Injection Pipe - Replace		*
	Oil Cooler - Clean		*
	Fresh Water Pump Unit Seal and Ball Bearing - Replace		*
	Sea Water Pump Unit Seal and Ball Bearing - Replace		*
	Thermostat - Replace		*
	Coolant Hose - Replace		*
	Fresh Water Tank Cap - Replace		*
	Turbocharger - Major Overhaul		*
	Electrical Components - Inspect		*
	Relays - Replace		*
	Marine Gear - Overhaul, Marine Gear Periodic Replacement Parts - Replace		*

Table 7-2 Periodic Maintenance Schedule

Service Intervals	Service Items	Page
Every 16000 hours or every 10 years	including items listed in every 100, 250, 500, 1000, 2000, 4000, and 8000 hours	-
	Replace the following parts with new ones: Piston, piston pin, rocker bushing, gear bushing, tappet, valve guide, valve spring, connection rod bolt, main bearing cap bolt, high-pressure fuel injection pipe, low-pressure fuel pipe, and oil pipe.	*
	Cylinder Head Bolt - Inspect	*

Note: (a) The items marked with an asterisk (*) in the maintenance schedule will require special tools and specialized maintenance work. Please contact your MHIET dealer for the maintenance of those items.

(b) Be sure to conduct periodic inspection at specified intervals, either service hours or years, whichever comes first.

Engine

Engine Exterior - Inspect

CAUTION

Check external parts of the engine, particularly hot parts (exhaust manifold and others), or the battery for accumulation of flammable materials. Also, check leaks of fuel and engine oil. Remove dust from the top surface of the battery. If hot parts have a problem, it may cause a fire. If any abnormality is found, be sure to repair or contact your MHIET dealer.

Inspect the engine exterior as instructed below:

1. Make sure there is no combustible material near the engine or battery. Also, check to make sure that the engine and battery are clean. If combustible materials or dust are found near the engine or battery, remove them.
2. Make sure fluids, such as fuel, oil, and coolant, are not leaking from the engine. If a leak is found, repair the leak, or contact your MHIET dealer.
3. Walk around the engine and check bolts and nuts for looseness.
4. Check electric wiring for disconnection, looseness, cuts, or rubbing.
5. Make sure the following valves, plugs, or cocks are properly positioned as indicated below:
 - Fuel feed valve: open
 - Coolant drain cock (valve): closed
 - Engine oil drain plug: closed

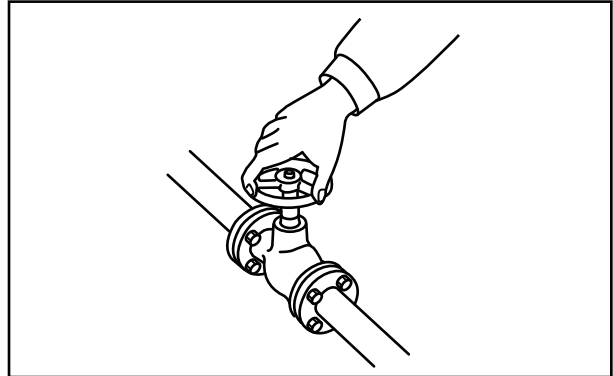


Fig. 8-1 Valve Open/Closed Position - Check

Belt and Belt Tension - Inspect and Adjust

CAUTION

If defects such as cuts or surface separations are found in the inspection, replace the belt.

Belts must be free from grease and oils. Grease and oils cause belts to slip and shorten their service life.

Excessive belt tension may cause rapid wear of the alternator bearing, and shorten the service life of the belt.

Adjust the belt tension properly by following the procedures below:

Belt - Inspect

1. Inspect the belt visually for peeling or breaks. If any abnormality is found, replace the belt with a new one.
2. Inspect the belt tension (deflection).
Push the belt downward at the midway between pulleys. If the deflection is 4 mm [0.16 in.], the tension is correct.
Force on the belt: alternator side = 20 ± 5 N { 2 ± 0.5 kgf} [4.50 $\pm$ 1.12 lbf],
sea water side = 39 ± 5 N { 4 ± 0.5 kgf} [8.77 $\pm$ 1.12 lbf]
If the belt deflection is not within the specified range, adjust the belt tension.

Belt Tension (Alternator Side) - Adjust

1. Remove the belt cover.
2. Loosen all retaining bolts of the alternator and adjusting plate.
3. Loosen the lock nut, and adjust the belt tension with the adjusting bolt.
4. Tighten the lock nut, and tighten all retaining bolts and nuts to fix the alternator and adjusting plate.
5. Install the belt cover.

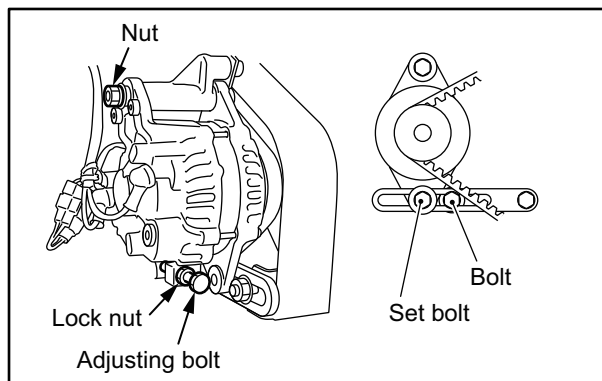


Fig. 8-2 Belt Tension (Alternator Side) - Adjust

Belt Tension (Sea Water Pump Side) - Adjust

1. Loosen all the bolts and nuts that fix the sea water pump.
2. Loosen the lock nut, and adjust the belt tension with the adjusting bolt.
3. Tighten the lock nut, and tighten all the bolts and nuts to fix the sea water pump.

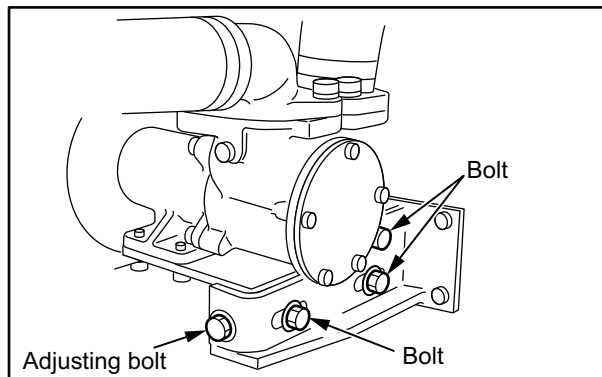


Fig. 8-3 Belt Tension (Sea Water Pump Side) - Adjust

Damper - Inspect

Damper - Check Visually

CAUTION

The protective cover for the damper should not be air-tight.

Installation of a closed cover may cause damage to the damper due to heat.

Visually check the damper for scratches, silicone oil leaks, and paint discoloration or peeling.

Note: If the damper is defective, contact your MHIET dealer.

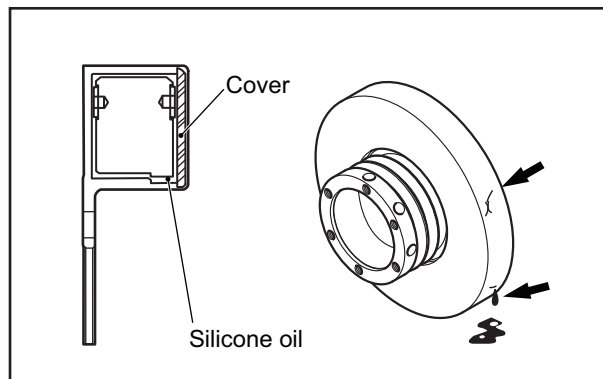


Fig. 8-4 Damper - Check Visually

Cold Weather Operations

In cold weather, engine oil gets thicker and the coolant can freeze. As a result, the engine fails to start, or the cylinder heads and heat exchanger may be damaged. To prevent such problems, follow the instructions given below:

Fuel



WARNING

When handling fuel, make sure there are no open flames or other fire hazards near the engine. Wipe off any spilled fuel completely. Spilled fuel may be ignited and cause a fire.

Replace oil with a low viscosity oil.

Use fuel that has a pour point suitable for the ambient temperature.

Note: For fuel, refer to "FUEL" (4-1).

Engine Oil

Use engine oil suitable for the ambient temperature of the engine.

Note: For engine oil, refer to "ENGINE OIL" (5-1).

Coolant



CAUTION

Never open the Fresh water tank pressure cap during the operation or immediately after stopping. Stop the engine and, after coolant has sufficiently cooled down, open the cap.

Place waste cloth over the Fresh water tank pressure cap, and loosen the cap about 1/4 turn to release the internal pressure.

The coolant is hot while the engine is running and immediately after stopping. If the cap is opened while the coolant is hot, you may get burned by bursts of steam. To avoid a steam burn, wear thick rubber gloves or wrap a cloth around the cap.

When fastening the Fresh water tank pressure cap, be sure to tighten securely.

In cold weather the coolant can be frozen, and it may cause damage to the crankcase. Therefore, be sure to use an all-season long life coolant that has anti-freeze and anti-rust protection for the cooling system.

Note: For coolant and LLC, refer to "COOLANT" (6-1).

Maintenance After Cold Weather is Over

When the cold weather ends, select the fuel, engine oil and coolant suitable for the ambient temperature referring to the specifications in this manual.

Sea Water - Drain

When the ambient temperature drops below 0°C [32°F], the sea water used to cool the engine can freeze and cause serious problems such as sea water pump damage. Drain sea water after engine operation.

For sea water draining, refer to "Sea Water - Drain" (8-18).

Fuel System

Fuel System - Inspect



WARNING

When handling fuel, make sure there are no open flames or other fire hazards near the engine.
Wipe off any spilled fuel completely. It may cause a fire.

Fuel Tank - Clean

CAUTION

For the fuel to be used, refer to "FUEL" (4-1).

1. Close the fuel feed valve to cut off the fuel supply to the engine.
2. Place a drip pan under the drain cock.
3. Drain all fuel in the tank from drain cock located at the bottom of fuel tank.
4. Clean the inside of fuel tank.
5. Add fuel to the fuel tank.
6. Open the fuel feed valve of the engine.

Note: If the specifications of fuel tank differs from the contents in this operation manual, obey the tank manufacturer's operation manual.

Fuel Tank - Drain Water

If fuel is contaminated with foreign substances such as dust, dirt, or water, it can cause not only decrease of output but also malfunctions of the fuel system. To avoid such problems, drain water from the fuel tank as instructed below:

1. Place a drip pan (capacity of 2 L [0.53 U.S. gal.] or more) under the drain cock of fuel tank.
2. Open the drain cock of fuel tank and drain fuel at least 1 to 2 L [0.26 to 0.53 U.S. gal.].
3. After making sure water and foreign material particles has been discharged together with fuel, close the drain cock.

Note: If the specifications of fuel tank differs from the contents in this operation manual, obey the tank manufacturer's operation manual.

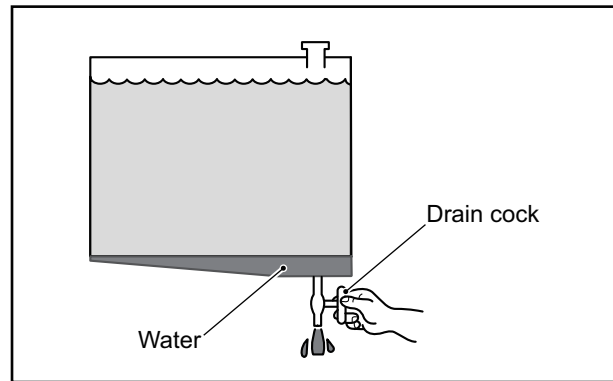


Fig. 8-5 Fuel Tank - Drain Water

Gauze Filter - Clean

If the gauze filter is clogged, the fuel supply becomes insufficient, resulting in decrease in power output or engine stall.

1. Remove the union bolt at the inlet port of fuel feed pump.
2. Using a screw driver, remove the gauze filter that is fitted inside the union bolt.
3. Soak the gauze filter in the fuel, and clean it with a brush.
4. Check the gauze filter for damage.
5. After cleaning, install the gauze filter into the union bolt using a screw driver.
6. Install the union bolt to the fuel feed pump.
7. Bleed air from the fuel filter.

Note: For bleeding the fuel filter, refer to ["Fuel Filter - Bleed Air" \(3-2\)](#).

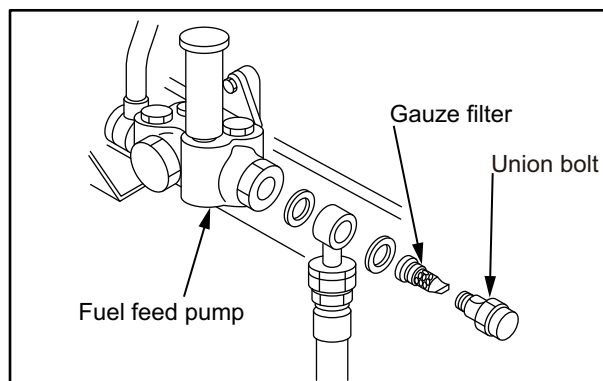


Fig. 8-6 Gauze Filter - Clean

Fuel Filter - Replace

1. Clean the area around the fuel filter.
2. Place a drip pan under the fuel filter.
3. Using a filter wrench, remove the fuel filter.
4. Wipe off fuel on the fuel filter cartridge mounting surface of the filter bracket with a waste cloth.
5. Prepare new fuel filter, and make sure that gasket is properly seated in the groove.



WARNING

If the filter case is dented, do not use the filter. The filter element in dented case may be damaged during operation, leading to fuel leaks, which eventually may result in a fire.

6. Apply clean fuel on the gasket of the new fuel filter.
7. Install the fuel filter on the filter bracket. When the gasket comes in contact with the mounting surface of the filter bracket, further rotate the filter by 3/4 to a full turn.

CAUTION

Hand tighten the fuel filter. Do not tighten with a filter wrench.

Be careful not to dent or scratch the fuel filter surfaces.

8. After the new fuel filter has been installed, bleed air from the fuel filter.

Note: To bleed air from the fuel filter, refer to "[Fuel Filter - Bleed Air](#)" (3-2).

9. Start the engine and run at an idle speed for several minutes.
10. Make sure that there is no fuel leak from the fuel filter mounting face. If the leak is found, loosen the fuel filter and check the gasket for damage. If there is no damage, tighten the fuel filter.

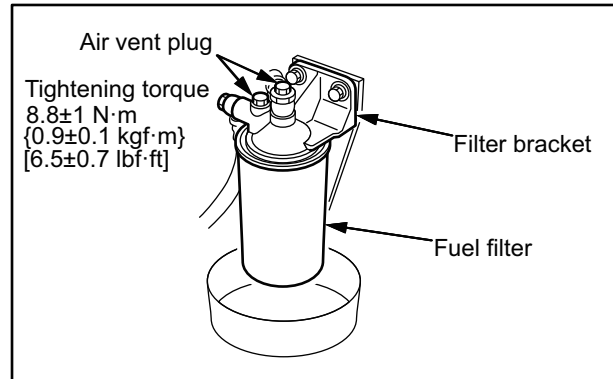


Fig. 8-7 Fuel Filter - Replace

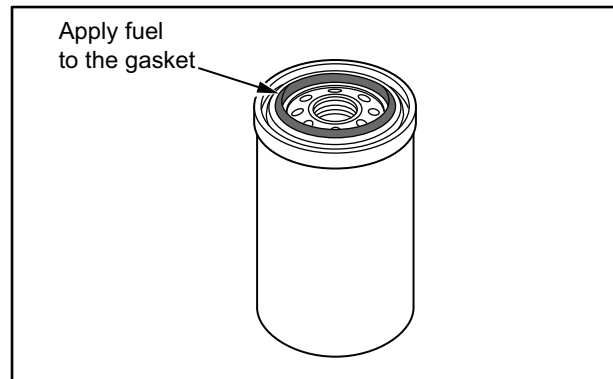


Fig. 8-8 Fuel Filter

Fuel Pipe - Inspect

High-pressure Fuel Injection Pipe and Clamp Seat - Inspect and Replace

Visual Inspection

Check the clamp seat for crack and wear. Check the high-pressure fuel injection pipe for wear. If defective, replace the clamp seat with a new one. Replace the high-pressure fuel injection pipe with a new one if needed.

Every Major Overhaul

Replace the clamp seat with a new one. Also, check the high-pressure fuel injection pipe for wear. If defective, replace the high-pressure fuel injection pipe with a new one.

Every Other Major Overhaul

Replace all the high-pressure fuel injection pipes with new ones.

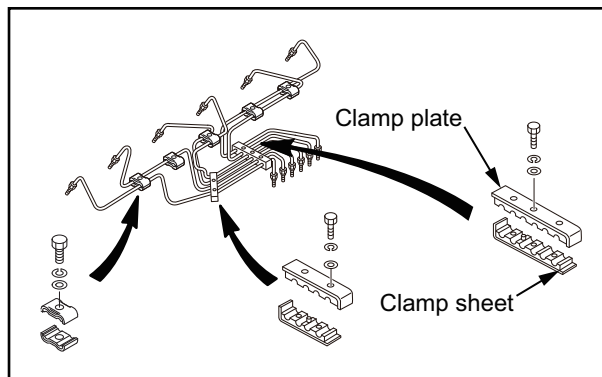


Fig. 8-9 High-pressure Fuel Injection Pipe and Clamp Seat - Inspect and Replace

Low-pressure Fuel Pipe, Oil Pipe, and Clip - Inspect and Replace

Visual Inspection

Loosen clamp retaining bolts and check for clip wear and metal contact between pipe and clamp. If defective, replace the pipe assembly with a new one.

Every Other Major Overhaul

Replace the pipe assembly with a new one.

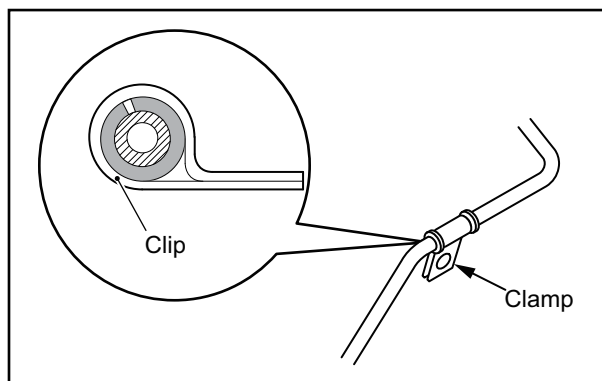


Fig. 8-10 Low-pressure Fuel Pipe, Oil Pipe, and Clip - Inspect and Replace

Lubrication System

Engine Oil, Oil Filter, and Bypass Oil Filter - Replace

CAUTION

Before draining engine oil, make sure the oil has cooled down.

When draining oil or replacing oil filters, be sure to wear gloves. Hot engine oil and parts may cause burns.

CAUTION

Do not dump drain oil casually into the sewage. It is prohibited by the laws and regulations. For the disposal of drained oil, contact your MHIET dealer.

Change the engine oil, oil filter, and bypass oil filter at a time.

Also, the engine oil analysis is recommended when you change the engine oil.

Do not reuse oil filter elements, as they are a paper type. When replacing filter elements, also replace gaskets with new ones.

Engine Oil - Drain

1. Connect the engine oil drain port and drain pump with a vinyl hose.
2. Operate the drain pump to drain engine oil.

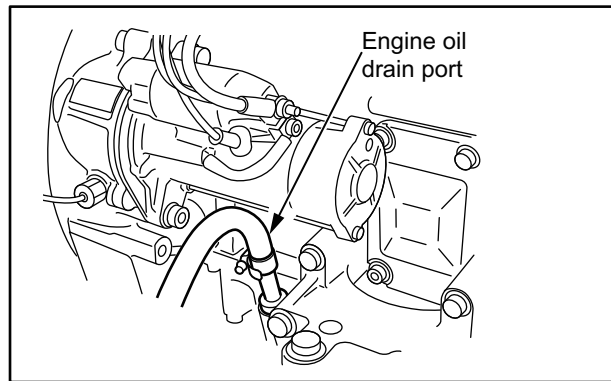


Fig. 8-11 Engine Oil - Drain Port

Oil Filter and Bypass Oil Filter - Replace

CAUTION

Replace the oil filter and bypass oil filter during not only regular inspection and maintenance intervals but also when the oil filter alarm light turns on.

1. Clean the area around oil filters.
2. Place oil pans under oil filters and bypass oil filter.
3. Remove the drain plug and drain the engine oil from the filter.
4. Remove the center bolt and remove the filter case and element.

Note: Cut off the oil filter elements and bypass oil filter elements that have been removed, and check elements. Consult with your MHIET dealer if metal particles are found in the elements.

5. Thoroughly wipe off oil on the oil filter mounting surface of the filter bracket with a clean cloth.
6. Prepare new filter elements, gaskets and O-rings. Be sure to use genuine parts.
7. Apply clean engine oil on gasket.
8. Install oil filters and bypass oil filter on the filter bracket. When the filter case comes into contact with the mounting surface of the filter bracket, further rotate the center bolt 1/2 to 3/4 turn.

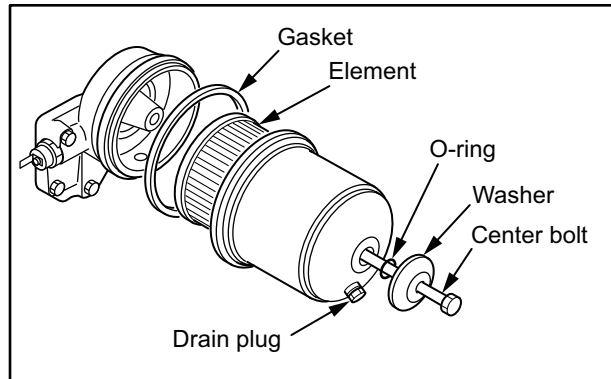


Fig. 8-12 Oil Filter - Change

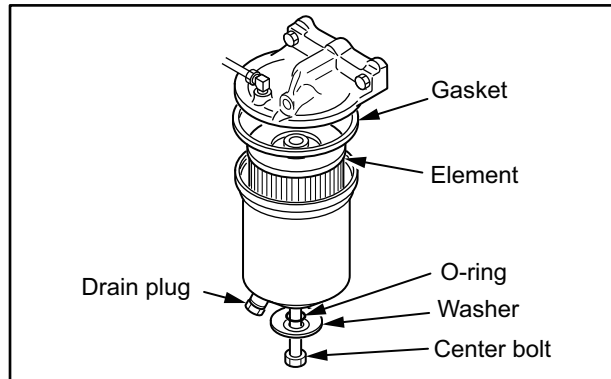


Fig. 8-13 Bypass Oil Filter - Change

Engine Oil - Refill

CAUTION

Fill the engine with the specified engine oil to the specified level. If the oil level is higher than the maximum mark on the level gauge, engine oil may blow out during operation. Also, the rise of oil temperature could adversely affect engine components.

1. Remove the oil filler cap.
2. Add the specified engine oil to the specified level.
Note: For engine oil, refer to **"ENGINE OIL" (5-1)**. For engine oil capacity, refer to **"MAIN SPECIFICATION" (12-1)**.

3. Check the oil level in oil pan.
4. Pull out the oil level gauge and wipe it clean with a cloth.
5. Insert the oil level gauge fully into the oil level gauge guide and then pull it out again.
6. The oil level should be between the maximum and minimum marks on the oil level gauge.
If the engine oil level is higher than the maximum mark on the oil level gauge, drain engine oil.
If the engine oil level is low, add the specified engine oil.
7. Check the oil pan and others for oil leaks. Repair if there is an oil leak.
8. With the stop lever placed in the pulled position, rotate the engine with starter for approx. 10 seconds to circulate oil to the engine thoroughly. Stop for 1 minute, then, repeat this operation two or three times to circulate oil to all parts of the engine.

Note: Perform this procedure after the preparation work for the lubrication and cooling systems have been finished.

9. Start the engine and run at no-load and low-idling condition for 5 to 10 minutes.
10. Stop the engine and leave it for 30 minutes or more, and then, check the oil level with the oil level gauge again and add oil to the specified level.
For details, refer to **"Test Operation" (3-6)**.

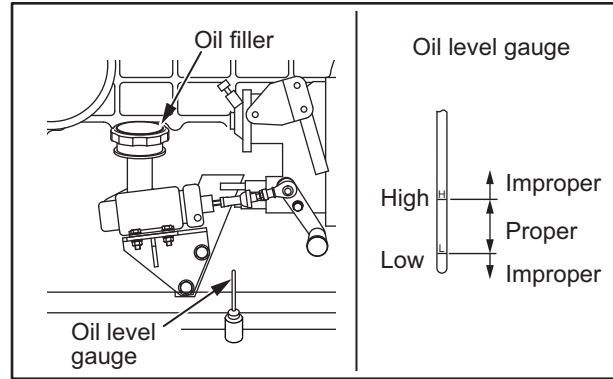


Fig. 8-14 Oil Filler and Oil Level Gauge

Ingress of Fuel and Water In Engine Oil - Inspect

CAUTION

If the engine operation is continued with fuel or water mixed in the engine oil, the engine oil viscosity will decrease and this may cause serious problems such as bearing seizure.

Extract 1 to 2 L [0.26 to 0.53 U.S. gal.] of engine oil, and check abnormal odor and discoloration to determine if the oil is contaminated with fuel or water.

If fuel is mixed, the oil will smell like fuel.

If water is mixed, oil may turn milky white.

If fuel or water is mixed with the engine oil, find the cause and repair. If the repair seems to be difficult, contact your MHIET dealer.

If the coolant enters the engine oil during operation, moisture vapor is discharged from the breather. In such a case, locate the fuel or water leak, and repair properly.

Note: If oil leaks from oil cooler, oil will float in water in the Fresh water tank. Also, LLC that is not mixed with oil will accumulate at the bottom of oil pan.

Marine Gear Oil - Change, Marine Gear Oil Strainer - Clean, Marine Gear Cover Oil Filter - Replace

Marine Gear Oil - Drain

CAUTION

Wear gloves when draining oil. If hot oil or parts touch your skin, it could cause burns.

1. Pull out the marine gear oil level gauge, and install a vinyl tube to the level gauge inserting pipe.
2. Drain the oil with an oil scavenging pump.

Note: (a) Marine gear draining is easy when the oil is warm after stopping the engine.

(b) If the specification of oil scavenging pump differs from the contents of this operation manual, follow the pump manufacturer's operation manual.

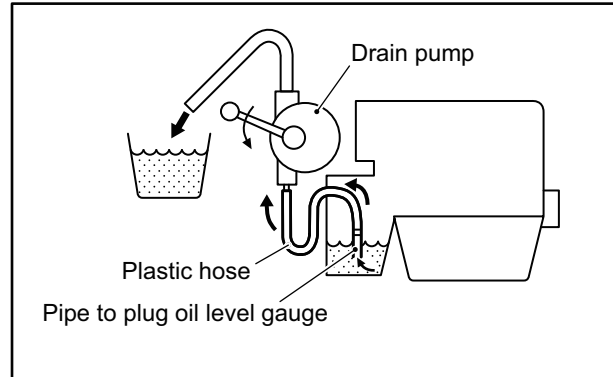


Fig. 8-15 Marine Gear Oil - Drain

Marine Gear Oil Strainer - Clean

1. Place a pan under the oil strainer to catch oil.
2. Remove the cover, and remove the element.
3. Soak the element in wash oil and remove foreign contamination attached to the outside with a soft brush.
4. Blow compressed air to the element and dry it thoroughly.
5. Install the element, and install the cover.

Note: If large amounts of iron are present in the strainer, contact our authorized dealer.

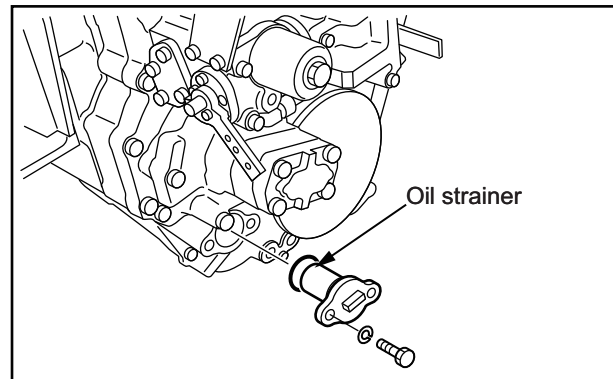


Fig. 8-16 Marine Gear Oil Strainer - Clean

Replace Marine Gear Governor Oil Filter

1. Remove the center bolt, and remove the filter case, spring and element.
2. Install an O-ring to the new element, tighten it to the governor block with the center bolt and sealing washer, and fix.

Note: Do not reuse the element by cleaning. Be sure to replace with a new one.

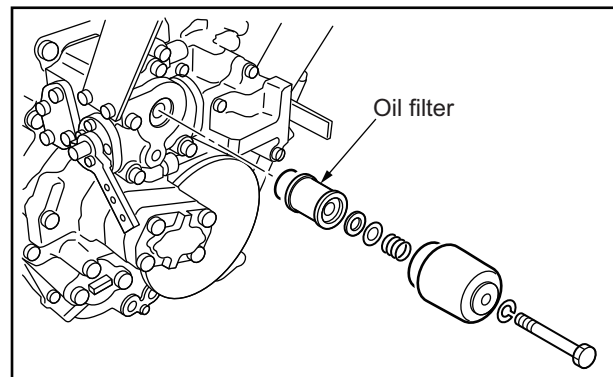


Fig. 8-17 Replace Marine Gear Governor Oil Filter

Marine Gear Oil - Filling

1. Fill oil to the specified level from oil filler port.
Specified oil: CF class, single-grade oil (SAE 30 or equivalent)
2. Install the plug to the oil filler port.
3. Run the engine at idle speed for approx. 5 minutes, and check for oil leaks from marine gears.
4. Run the engine at low idle and check the oil level.
5. Make sure that oil level on the level gauge is between "maximum" and "minimum" lines.

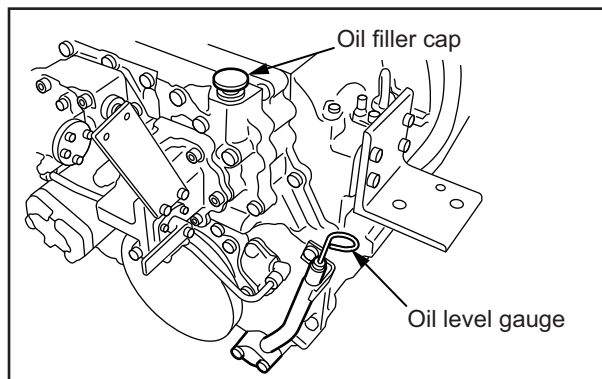


Fig. 8-18 Marine Gear Oil Filler Cap and Marine Gear Oil Level Gauge

Cooling System

Coolant - Change

CAUTION

Do not dump used coolant (containing LLC) down drains.
Such a way of disposal is strictly prohibited by laws and regulations.
Abide by the applicable laws and regulations for disposal of coolant.

CAUTION

When a coolant mixed with the LLC recommended by our company is used, replace coolant every 8000 hours or 2 years, whichever comes first.

Fresh Water Tank Pressure Cap - Open/Close

CAUTION

Never open the Fresh water tank pressure cap during the operation or immediately after stopping. If you open the cap when the coolant is hot, there is a risk of getting burned if steam or boiling water comes out. Stop the engine, and after the coolant has sufficiently cooled down, then, open the cap.

To open the Fresh water tank pressure cap, wear thick rubber gloves, or place a waste cloth over the cap, and turn the cap 1/4 turn to release the internal pressure.

When fastening the Fresh water tank pressure cap, be sure to tighten securely.

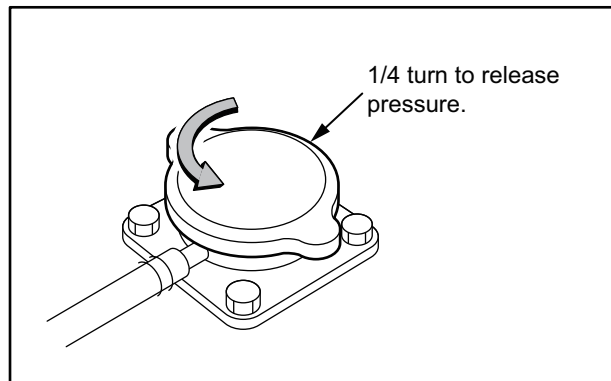


Fig. 8-19 Fresh Water Tank Pressure Cap

Coolant - Drain

1. After making sure the engine has cooled, open the Fresh water tank pressure cap.
2. Prepare a can that catches coolant, and open the drain cocks and plugs to drain the coolant.

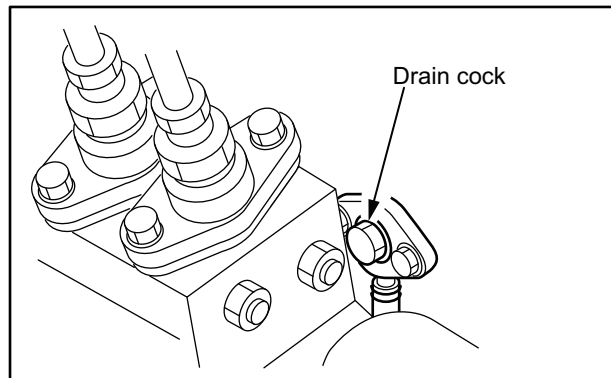


Fig. 8-20 Coolant Drain Cock (Engine Body)

Cooling System - Clean

CAUTION

Wash the cooling system before operating the engine for the first time, or before starting the engine after it has been in storage under coolant drained condition.

1. Close coolant drain cocks and plugs.
2. Pour a cleaning solution (a solution that is non-corrosive to rubber and metals) into the cooling system, and operate the engine at 800 to 900 min⁻¹ for about 15 minutes, then drain the cleaning solution.
3. Close coolant drain cocks and plugs.
4. Add fresh water and operate the engine at 800 to 900 min⁻¹ for about 10 minutes.
Repeat the above rinsing steps until the draining water becomes clear and clean.

Coolant - Refill

CAUTION

To add coolant, use the same LLC concentration coolant that is currently in the cooling system.

1. Securely close the engine coolant drain cock.
2. Open the coolant filler port and add a mixture of water and coolant (LLC) having the specified concentration.

Note: Determine the quantity of LLC based on the coolant capacity and the LLC concentration chart.

For the coolant, refer to "COOLANT" (6-1). For the coolant capacity, refer to "MAIN SPECIFICATION" (12-1).

3. Check the heat exchanger, etc. for coolant leaks. Repair if a leak is found.
4. When the coolant reaches the specified level, securely close the coolant fill port.
5. With the stop device such as a manual stop lever activated, crank the engine for approx. 10 seconds using the starter. Stop for approximately 1 minute, and then repeat the cranking 2 or 3 times to bleed air from the cooling system.

Note: Also, perform the items described under the Preparation of Lubrication System.

6. Check the coolant level.
7. Also, fill the reserve tank with coolant up to the "FULL" level line.

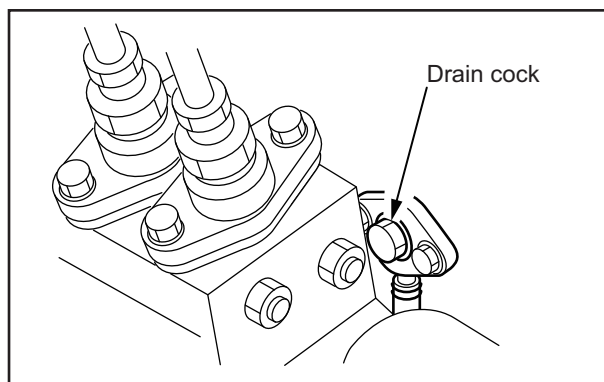


Fig. 8-21 Coolant Drain Cock (Engine Body)

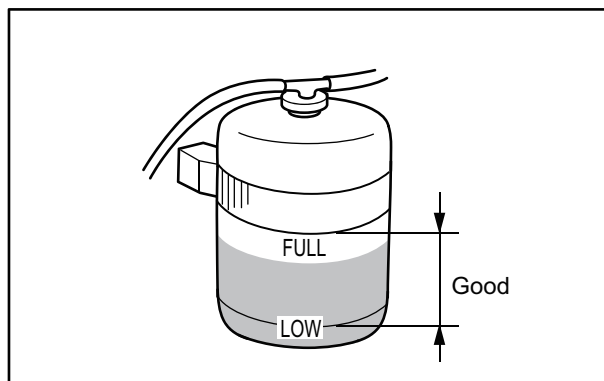


Fig. 8-22 Reserve Tank Coolant Level

Fresh Water Pump - Lubricate



WARNING

Thoroughly wipe off excess grease, as it can cause a fire.

1. Remove the cap from the grease cup.
2. Using a grease gun, fill the cup with grease fully.
3. Install the cap on the grease cup.

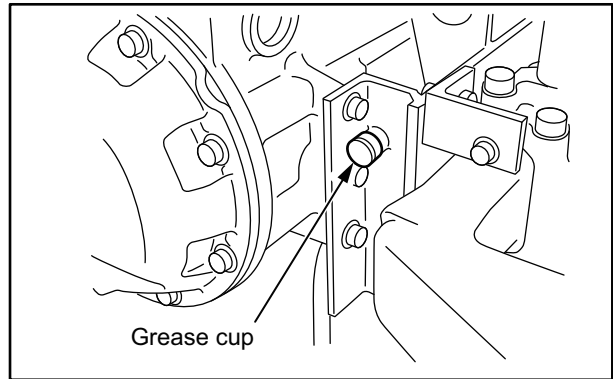


Fig. 8-23 Fresh Water Pump - Lubricate

Sea Water - Drain

When the ambient temperature drops below 0°C [32°F], the sea water used for cooling the engine can freeze and cause serious problems such as sea water pump damage. To prevent such problems, drain the sea water after using the engine by following the instructions below.

1. Make sure that the kingston valve is closed.
2. Open the sea water drain cock or remove the plug, and drain sea water.
3. Remove the sea water pump cover, and drain sea water from the sea water pump.

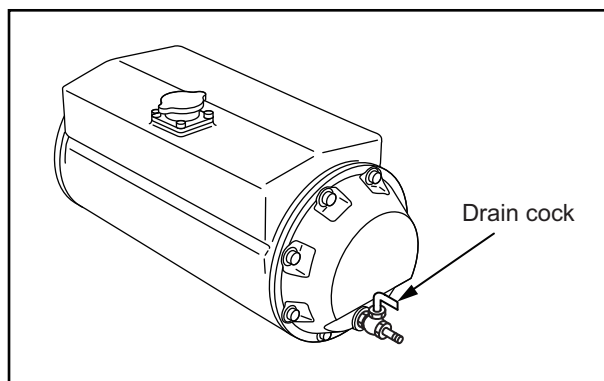


Fig. 8-24 Sea Water Drain Cock (Heat Exchanger)

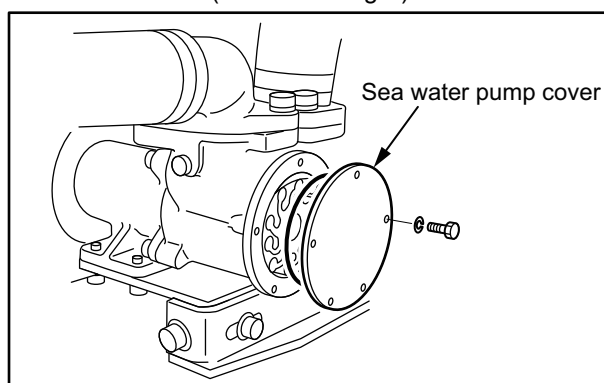


Fig. 8-25 Sea Water Pump Cover

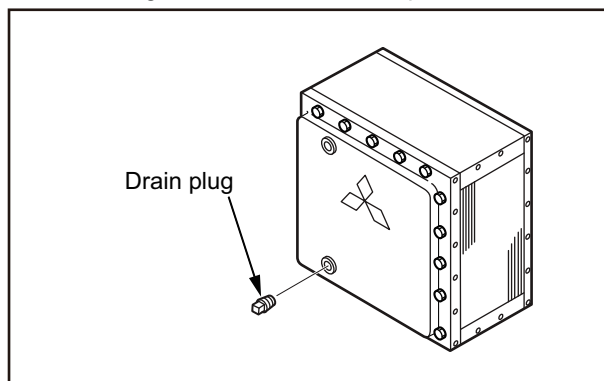


Fig. 8-26 Sea Water Drain Plug (Intercooler)

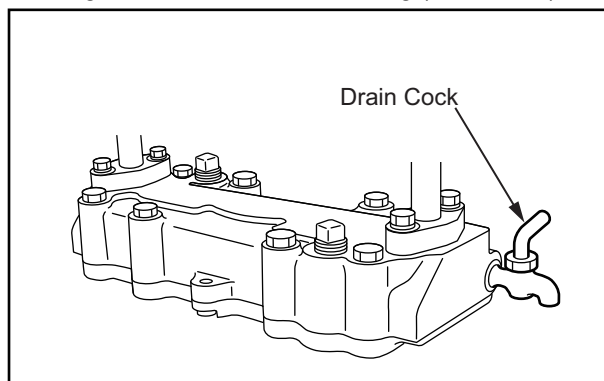


Fig. 8-27 Sea Water Drain Plug (Marine Gear Oil Cooler)

Sea Water Pump Impeller - Inspect

CAUTION

When installing the impeller, pay attention to the orientation of impeller blades. The impeller may be broken if it is incorrectly installed.

1. Remove the sea water pump cover.
2. Remove the impeller using a puller.
3. Check the impeller for damage, cracks, and if any defects are found, replace the impeller with a new one.
Check the inside the case, and if damaged, replace it with a new one.
Check the cam, and if damaged or worn, replace it with a new one.
4. While paying attention to the orientation of impeller, install the impeller to the sea water pump case.
5. Install the cover with O-ring to the pump case.

Note: Because of simple structure, the puller is not included in the special tools. Please use commercially available puller or make it by yourself.

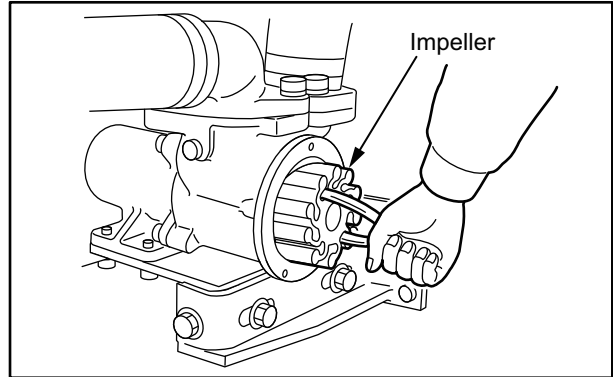


Fig. 8-28 Sea Water Pump Impeller - Inspect

Zinc Rod - Inspect

Zinc rods (zinc electrodes) are installed at various sections of the sea water passage to prevent corrosion caused by sea water.

1. Remove each zinc rod and remove deposits (scale) from the surface of rod.
2. If the zinc rod has worn to half the original size, replace it with a new zinc rod. If the zinc rod is not less than half the original size, reinstall it.

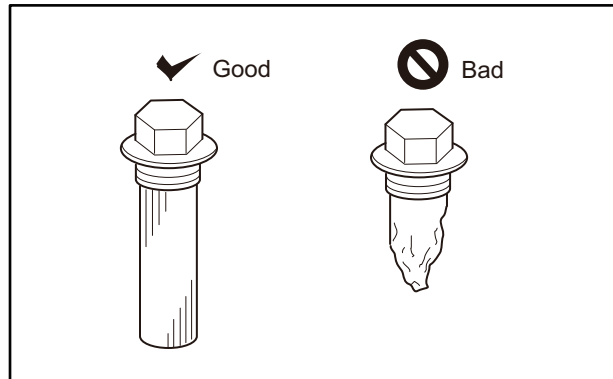


Fig. 8-29 Zinc Rod - Judge

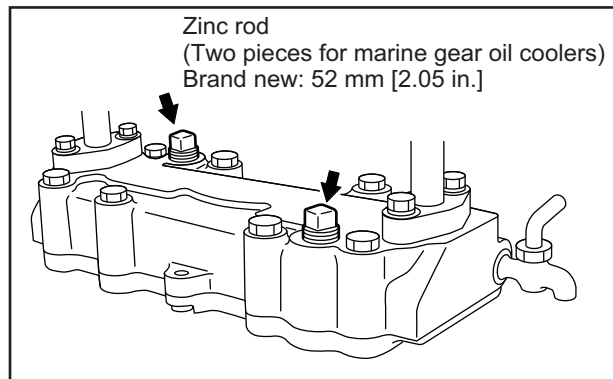


Fig. 8-30 Zinc Rod Mounting Location (Marine Gear Oil Cooler)

Inlet and Exhaust Systems

Turbocharger - Inspect

CAUTION

Inspect the turbocharger when the engine is cold. Before inspection, make sure that the compressor wheel is not rotating.

CAUTION

The turbocharger inspection should be also conducted if the color of the exhaust gas is abnormal. Do not allow foreign objects to enter the turbocharger.

Disconnect the pipe on the inlet side. Hold the compressor wheel nut by hand and move in the axis direction and from right to left and up and down to check for looseness or contact with surrounding parts. Turn the wheel to check if it rotates smoothly. Replace if defective.

Note: When the inspection requires the removal of turbocharger, contact your MHIET dealer. Also, check the compressor wheel fins for discoloration and breaks, and check for rubbing between compressor wheel and housing.

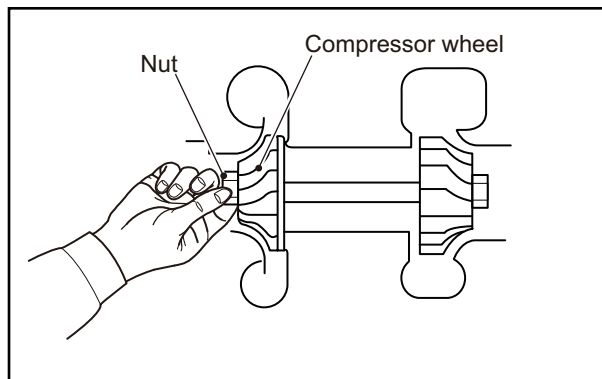


Fig. 8-31 Turbocharger - Inspect

Pre-cleaner - Clean, Inspect, and Replace

CAUTION

Never conduct the maintenance of pre-cleaners during engine operation. If foreign particles enter the engine, it accelerates wear of parts and shortens the service life of the engine.

The pre-cleaner that is attached to the silencer of the turbocharger catches foreign particles included in intake air and keep the engine in clean condition for optimum performance. Always keep it clean as instructed below.

1. Remove the pre-cleaner from the silencer, and hand-wash the pre-cleaner with a mild detergent.
2. Rinse the pre-cleaner with fresh water.
3. After drying thoroughly, inspect the pre-cleaner for damage such as breaks. If breaks are found, replace the pre-cleaner with a new one.
4. After cleaning, inspection, or replacement, install the pre-cleaner to the silencer.

Note: If the pre-cleaner is torn, getting thinner or stretched due to cleaning, replace it with a new one.

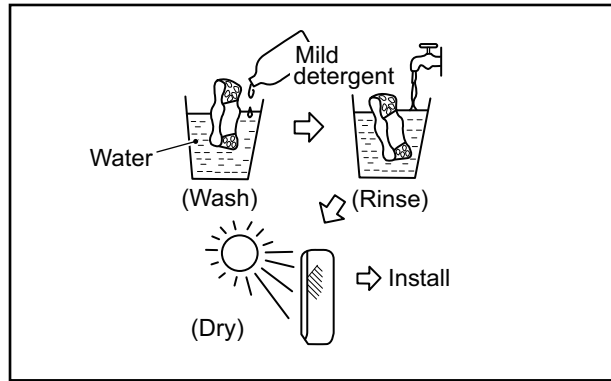


Fig. 8-32 Pre-cleaner - Wash

Electrical System

Battery - Check

⚠ CAUTION

- ♦Never use flames or allow sparks near the battery. The battery releases flammable hydrogen gas and oxygen gas. Any flames or sparks near the battery may cause an explosion.
- ♦Do not use the battery when the battery fluid level is below the "LOWER LEVEL" mark. It may explode.
- ♦Do not short the battery terminals with a tool or other metal object.
- ♦When removing battery, always remove the plug from the negative (-) terminal first. When connecting battery, always connect the plug to the positive (+) terminal first.
- ♦Before charging the battery, remove all battery cables, and then charge the battery in a well-ventilated area.
- ♦Make sure the cable clamps are securely attached to the battery terminals. A loose cable clamp may cause sparks, and it may result in an explosion.
- ♦Before servicing electrical components or conducting electric welding, set the battery switch to the [OFF] position or remove the plug from the negative (-) terminal to cut off the electrical current.
- ♦Battery fluid contains dilute sulfuric acid. Careless handling of the battery may cause a sight loss and/or skin burns. Also, do not swallow the battery fluid.
- ♦Wear protective goggles and rubber gloves when working with the battery (e.g. when adding water or charging battery).
- ♦If battery fluid is spilled onto the skin or clothing, immediately wash it away with lots of water. Use soap to clean thoroughly.
- ♦The battery fluid may cause sight loss if splashing into the your eyes. If it gets into your eyes, immediately flush it away with plenty of clean water, and seek immediate medical attention.
- ♦If you accidentally swallow battery fluid, gargle with plenty of water and then drink lots of water, and seek immediate medical attention.
- ♦If the battery does not fully recover after charging for 24 hours or more, do not use the battery.

Note: If the specification of battery differs from those of this operation manual, follow the battery manufacturer's operation manual.

Battery Fluid Level - Check

The battery fluid evaporates during the use, and the fluid level gradually decreases. The proper fluid level is between the LOWER LEVEL (Lower limit) and UPPER LEVEL (Upper limit) marks.

For the battery without level marks, the proper fluid level is about 10 to 15 mm [0.39 to 0.59 in.] above the top face of the polar plates.

If the battery fluid level is low, remove the cap, and add distilled water to the proper level.

Note: When adding distilled water, add little by little.

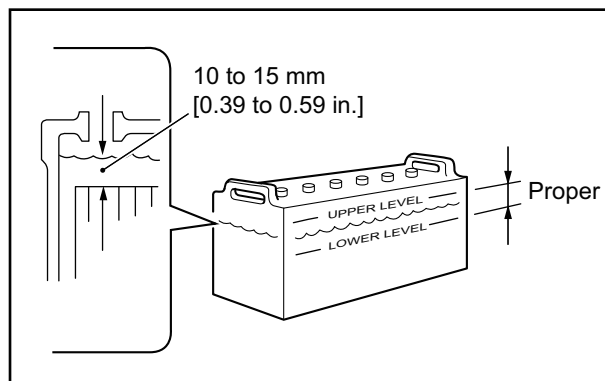


Fig. 8-33 Battery Fluid Level - Check

Specific Gravity of Battery Electrolyte - Check

If the specific gravity of battery fluid measured at 20°C [68°F] is lower than 1.22, charge the battery.

Table 8-1 Specific Gravity of Battery Electrolyte

Specific gravity at 20°C [68°F]	Condition	Remedy
From 1.26 to 1.28	Good	-
From 1.22 to less than 1.26	Almost good	Charge
Less than 1.22	Not good	Charge

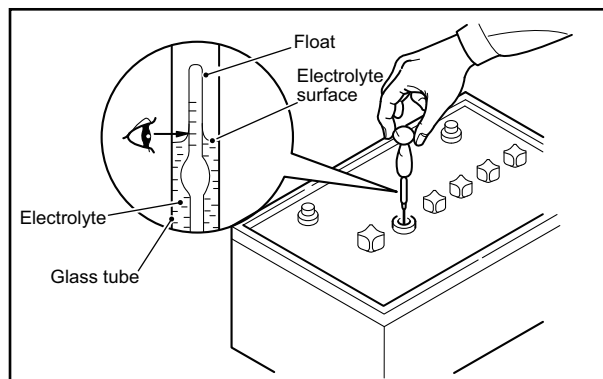


Fig. 8-34 Specific Gravity of Battery Electrolyte - Check

Starter - Inspect

Visually inspect the starter and ring gear for damage.

Note: If the starter is defective, contact your MHIET dealer.

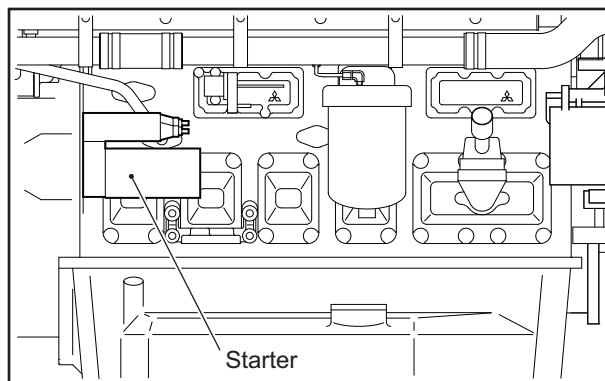


Fig. 8-35 Starter - Inspect

Alternator - Inspect

Visually inspect the alternator for damage.

Remove the belt and turn the pulley by hand to check the smooth rotation. Check the pulley for wear.

Also, visually inspect the inside of alternator for dust and salt accumulation since the alternator is an air cooling type.

Note: If the alternator is defective, contact your MHIET dealer.

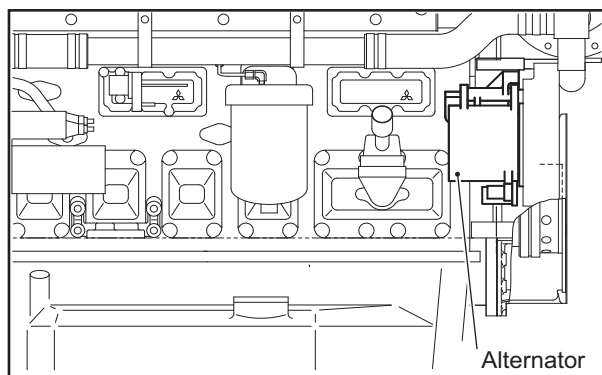


Fig. 8-36 Alternator - Inspect

Chapter 9 LONG-TERM STORAGE

CAUTION

If the engine is not in use for more than 3 months, the internal engine parts can rust, and it may cause damage to the engine. For long-term engine storage, be sure to follow the instructions below:

Storing Engine in an Inoperable Condition for 3 Months up to 1 Year

Preparation for Storage

1. Drain engine oil, and fill the engine with new oil.
2. Make a fuel mixture containing 50% rust-proof fuel (NP-9) and run it as quickly as possible at the rated speed.
3. After stopping the engine, suck a vaporizing rust inhibitor (VCI) into the air supply system (approximately 5 g [0.18 oz] for the direct model and approximately 10 g [0.35 oz] for the V model) and crank the engine twice or more.
4. Fill the fuel tank with fuel to protect the fuel tank from rusting. However, it is not necessary for FRP tanks.
5. Apply a sufficient quantity of anti-rust oil (NP-3-2) on the exposed machined surfaces.
6. Cover the air inlet, exhaust outlet, breather, etc. with adhesive cloth tape or plastic film.
7. Loosen the belt.
8. Apply a thin coat of grease on the starter and alternator terminals, and cover the openings. Also place desiccants inside the openings, and cover the openings with polyethylene sheet or processed polyethylene paper.
9. Disconnect the cables from the battery terminals, and charge the battery. Clean the terminals, apply a thin coat of grease on the terminals, and store in a cool and dry room.
10. Cover the entire engine.

Note: (a) Store the engine in a well-ventilated and dried indoor environment.

(b) It is not necessary to drain coolant since it contains LLC. (LLC must be the specified concentration. For LLC concentration, refer to "[LLC Concentration \(GLASSY and PG GLASSY\)](#)" (6-6).)

(c) Post a sign at an easily noticeable place to warn that the fuel tank must be filled before operation of the engine for the first time after storage.

Recommended Rust-Preventive Oil and Corrosion Inhibitor

Table 9-1 Table for Recommended Rust-Preventive Oil and Corrosion Inhibitor

JIS		Recommended product	Intended use
K 2246	NP-3-2	ANTIRUST TERAMI SC by ENEOS Corporation	Exposed machined surfaces
	NP-9	ANTIRUST TERAMI LN by ENEOS Corporation	Prevention of rust in fuel system
	NP-10-2	ANTIRUST P-230 by ENEOS Corporation	Prevention of rust in lubricating system
Z 1519	-	VCI Diana ND volatile corrosion inhibitor by Mitsubishi Gas Chemical Trading, Inc.	Prevention of rust in air intake system

Maintenance During Storage

Charge the battery once a month. Check battery fluid level, and then charge the battery.

When Using Engine After Storage

1. Remove the cover that has been placed over the entire engine.
2. Remove the covers from the starter and alternator.
3. Tension the belt.

Note: For the belt tension adjustment, refer to ["Belt and Belt Tension - Inspect and Adjust" \(8-2\)](#).

4. Remove the sealing tapes that have been covered the openings of the engine.
5. Connect pipes and hoses.

Note: For the engine oil, refer to ["ENGINE OIL" \(5-1\)](#).

6. Refuel it.
7. Inspect every part of the engine.
8. Remove the rocker covers, and lubricate the valve mechanism.
9. Connect a fully charged battery.
10. Make sure the engine oil pressure rises.
11. Warm up the engine until the engine oil fully lubricates each part of the engine.

Note: For engine starting procedure, refer to ["Start-up" \(3-13\)](#).

12. Operate the engine under load.

Storing Engine in an Operable Condition

If the engine is not be used for an extended period of time, internal engine parts can rust and lose oil film. As a result, the engine may seize when it is started. To prevent such risks, the engine must be operated periodically.

Operation for Maintenance Purpose

Operate the engine at least once a month as instructed below:

1. With the manual stop lever placed in the pulled position, crank the engine for approx. 10 seconds using the starter. Stop the operation for approx. 1 minute, then, repeat the operation two or three times.
2. After starting, make sure the engine oil pressure rises.
3. Operate the engine about 5 to 10 minutes at no load.

Note: For engine starting procedure, refer to ["Start-up" \(3-13\)](#).

Lifting Engine

When using the crane, the person who has obtained the crane operator license and also have a certificate of the crane operating skill training must operate the crane to raise the engine. Also when using a mobile crane, the person must have a certificate of mobile crane special training.



WARNING

To lift the engine, use wire ropes, shackles and slings capable of supporting the weight of the engine.

Hitch slings to the hangers provided on the engine to lift the engine.

Consider the engine's center of gravity and maintain the balance during lifting.

The hangers attached to the engine are designed for lifting the engine only. When lifting the engine equipped with a marine gear, etc., take care so that the load is not imposed only on the hangers of the engine.

Keep wire rope sling angles within 60 degrees. If the angle exceeds this limit, excessive load will be imposed on the hangers and this could damage the hangers and result in a serious accident.

Attach wire ropes to the hangers after removing pipe covers and insulators near the hangers. To prevent damage to the engine and wire ropes, use a cloth or other soft padding so that the wire ropes will not come in contact with the engine.

General Precautions

Contact Your MHIET Dealer for Repair Service

Except for relatively simple maintenance work such as changes and refilling of fuel, engine oil, and coolant, the repair work of the faulty engine may require special equipment or involves dangerous work. If the engine failed, contact your MHIET dealer.

Considerations Before Proceeding with Corrective Action

Before taking any actions, consider possible causes of the problem and try to find out if the same problem has occurred in the past.

Check the parts that may be causing the problem in the most efficient manner.

When disassembling any part of the engine, pay close attention to the disassembly sequence so that you can effectively assemble as they were.

Cautions Against Contamination

Dust and foreign materials are the most common cause of rapid wear of parts.

When disassembling any part of the engine, take measures to prevent dust and foreign materials from entering.

Cautions for Parts Handling

Handle parts carefully.

When replacing the part with a new one, order only the genuine MHIET part by referring to the parts catalogue.

Safety Working Practices

Be sure to use wrenches of the correct size. Using a wrench of the wrong size can cause damage to nuts and also may result in injury.

Use correct tools, and perform work with the utmost care.

Be sure to accurately estimate the weight of the part being dismantled. If the removed part is much heavier than you have estimated, it may fall off during lifting and can result in the damage to the parts or personal injury.

Troubleshooting

Tends To Overheat

CAUTION

Remove the Fresh water tank pressure cap only after the engine has cooled down sufficiently. To open the Fresh water tank pressure cap, open slowly to release pressure. Do not open the Fresh water tank pressure cap while the engine is hot to avoid burns due to hot steam and water.

Do not stop engine immediately after hard or extended operation. The engine may be seized due to the coolant temperature rise. Be sure to run the engine at a low idle speed to cool the engine.

Add coolant gradually after the engine has completely cooled. Do not add coolant while the engine is hot. Cylinder head, etc. could be damaged.

The coolant temperature rise warning light comes on (the warning buzzer also goes off) if the engine overheats. If you keep operating the engine uninterrupted with load, it will lead to problems such as knocking, lubrication failure, or seizure. Follow the instructions below when the engine overheats.

1. Stop sailing (or work) at once, and run the engine at a low idle to cool down the engine.
2. After stopping the engine, and only after the engine has completely cooled, add coolant up to the Fresh water tank pressure cap neck.
3. Check the followings:
 - ♦Cooling freshwater capacity
 - ♦Leaks from cooling system
 - ♦Belt tension and damage
 - ♦Sea water pump impeller damage

If you have not found any problems after checking above, consult with your MHIET dealer.

When Engine Oil Pressure is Abnormal

If the engine continues to be operated under abnormal decrease in engine oil pressure, it could lead to bearing seizure, etc. If the lubrication oil pressure warning light glows with warning buzzer, stop the engine at once, and follow the instructions below.

Table 11-1 When Engine Oil Pressure is Abnormal

Inspection item	Remedy	Referred page
Engine oil level decrease	Refill	8-11
Oil viscosity is too low	Use engine oil of appropriate viscosity suitable to ambient temperature	5-4
Clogged oil filter	Oil Filter - Replace	8-9
Engine oil leaks	Contact your MHIET dealer.	
Lubricating oil pressure warning light failure		

Note: In general, immediately after starting the engine, oil pressure gauge reads higher the normal pressure because the oil temperature is low. The pressure will be back to the normal pressure as the temperature rises.

When Marine Gear Oil Pressure is Abnormal

If abnormal pressure decrease in marine gear oil occurs, do not keep operating the engine. Clutch malfunction or gear damage could occur.

Stop the engine at once, and follow the instructions below.

Table 11-2 When Marine Gear Oil Pressure is Abnormal

Item to be inspected	Remedy	Reference page
Decrease in marine gear oil	Refill.	8-14
Oil viscosity is too low	Use engine oil of appropriate viscosity according to ambient temperature.	5-4
Clogged oil strainer	Clean oil strainer.	8-13
Clutch oil leaks	Contact a dealer of MHIET.	

While Being Towed or During Towing

If the ship is involved in a accident and has to be towed, it is not necessary to operate the engine, because the propeller drives the output shaft, thus, marine gear will be operated without lubrication. If the ship is going to be towed for more than one hour, secure the propeller shaft to prevent it from rotating, or pour the marine gear oil up to the center of input shaft.

Problems, Probable Causes, and Solutions

The Starter Does not Crank or Cranks Slowly, Resulting in Start Failure

Table 11-3 The Starter Does not Crank or Cranks Slowly, Resulting in Start Failure

Cause		Remedy
Electrical system	Faulty wire connection	♦Fuse - Inspect ♦Wiring connection of each relay between battery, starter, and starter switch - Inspect
	Battery charge failure	♦Alternator - Inspect (Refer to P8-24.) ♦Belt - Inspect and Adjust (Refer to P8-2.)
	Weak battery	♦Specific gravity of battery electrolyte - Check (Refer to P8-23.) ♦Battery - Charge ♦Battery - Replace
	Faulty starter or faulty safety relay	♦Contact your MHIET dealer.
Lubricating system	Oil viscosity too high	♦Use appropriate engine oil. (Refer to P5-1.)
	Excessive oil level	♦Engine oil level - Check (Refer to P3-10.)
Engine body	Sliding parts rapid wear or lock	♦Contact your MHIET dealer.

Note: The table above also includes the parts that MHIET does not supply. For inspection and maintenance of the parts that are not supplied by MHIET, follow the instructions in the supplier's operation manual.

Starter Cranks, but Engine Does Not Start

Table 11-4 Starter Cranks, but Engine Does Not Start

Cause		Remedy
Fuel system	Run out of fuel, blocked pipe	•Fuel Tank - Inspect, Refill, and Bleed Air (Refer to P8-5.) •Fuel Pipes and Valves - Inspect
	Improper fuel properties	•Use appropriate fuel. (Refer to P4-1.) •Dust, water, or impurities - Remove (Refer to P8-5.)
	Fuel leaks from fuel line or injection pipe	•Fuel lines and injection pipes - Check and Tighten •Contact your MHIET dealer.
	Clogged fuel filter	•Fuel filter - Inspect and Replace (Refer to P8-7.) •Gauze filter - Clean (Refer to P8-6.)
	Fuel feed pump malfunction	•Contact your MHIET dealer.
	Fuel injection pump malfunction	•Fuel injection pump rack stroke - Inspect •Contact your MHIET dealer.
	Fuel injection nozzle malfunction	•Contact your MHIET dealer.
Air intake system	Insufficient amount of intake air	•Inlet system - Clean and Inspect •Contact your MHIET dealer.
Control system	Governor malfunction	•Fuel control link - Check •Contact your MHIET dealer.
Engine body	Compression pressure drop	•Contact your MHIET dealer.

Note: The table above also includes the parts that MHIET does not supply. For inspection and maintenance of the parts that are not supplied by MHIET, follow the instructions in the supplier's operation manual.

Insufficient Output

Table 11-5 Insufficient Output

Cause		Remedy
Fuel system	Improper fuel properties	•Use appropriate fuel. (Refer to P4-1.)
	Clogged fuel filter	•Fuel filter - Inspect and Replace (Refer to P8-7.) •Gauze filter - Clean (Refer to P8-6.)
	Fuel feed pump malfunction	•Contact your MHIET dealer.
	Fuel injection pump malfunction	•Contact your MHIET dealer.
	Fuel injection nozzle malfunction	•Contact your MHIET dealer.
	Faulty fuel injection timing	•Fuel injection pump drive coupling - Inspect •Contact your MHIET dealer.
	Improper maximum injection volume	•Fuel injection pump rack stroke - Inspect •Contact your MHIET dealer.
Cooling system	Overheating or overcooling	•Belt - Inspect and Adjust Tension (Refer to P8-2.) •Sea water pump impeller and drive shaft - Inspect (Refer to P8-19.) •Heat exchanger - Inspect •Control system - Inspect •Contact your MHIET dealer.
Inlet and exhaust systems	Insufficient amount of intake air	•Turbocharger - Inspect (Refer to P8-20.) •Pre-cleaner - Clean, Inspect, and Replace (Refer to P8-21.) •Intake air pressure and intake air leaks - Inspect •Intake air temperature - Inspect •Contact your MHIET dealer.
	Increase of exhaust resistance	•Exhaust pipe - Inspect •Contact your MHIET dealer.
Engine body	Compression pressure drop	•Contact your MHIET dealer.
	Faulty valve timing	•Contact your MHIET dealer.
	Rapid wear of sliding parts	•Contact your MHIET dealer.
Control system	Governor malfunction	•Contact your MHIET dealer.
Rig	Excessive load	•Propeller and propeller shaft - Inspect •Deposits - Remove

Note: The table above also includes the parts that MHIET does not supply. For inspection and maintenance of the parts that are not supplied by MHIET, follow the instructions in the supplier's operation manual.

Exhaust Smoke is White or Blue

Table 11-6 Exhaust Smoke is White or Blue

Cause		Remedy
Fuel system	Improper fuel properties	•Check cetane index, and use appropriate fuel. (Refer to P4-2.)
	Faulty fuel injection timing	•Fuel injection pump drive coupling - Inspect •Contact your MHIET dealer.
	Fuel injection nozzle malfunction	•Contact your MHIET dealer.
	Uneven volume of fuel injection	•Ignition noise and exhaust smoke temperature - Inspect •Contact your MHIET dealer.
	Incorrect fuel injection timing	•Contact your MHIET dealer.
Lubrication system	Combustion of engine oil	•Engine oil level - Check (Refer to P3-10.) •Contact your MHIET dealer.
Cooling system	Overcooling	•Control system - Inspect •Thermostat - Inspect •Contact your MHIET dealer.
Engine body	Faulty valve timing	•Contact your MHIET dealer.
	Compression pressure drop	•Contact your MHIET dealer.

Note: The table above also includes the parts that MHIET does not supply. For inspection and maintenance of the parts that are not supplied by MHIET, follow the instructions in the supplier's operation manual.

Exhaust Smoke is Black or Gray

Table 11-7 Exhaust Smoke is Black or Gray

Cause		Remedy
Fuel system	Improper fuel properties	•Use appropriate fuel. (Refer to P4-1.)
	Fuel feed pump malfunction	•Contact your MHIET dealer.
	Fuel injection pump malfunction	•Contact your MHIET dealer.
	Fuel injection nozzle malfunction	•Contact your MHIET dealer.
	Faulty fuel injection timing	•Fuel injection pump drive coupling - Check •Contact your MHIET dealer.
	Irregular fuel injection quantity	•Exhaust gas temperature - Check •Contact your MHIET dealer.
Inlet and exhaust system	Insufficient amount of intake air	•Turbocharger - Inspect (Refer to P8-20.) •Pre-cleaner - Clean, Inspect, and Replace (Refer to P8-21.) •Intake air pressure, intake air leaks - Check •Intake air temperature and ventilation system - Check •Contact your MHIET dealer.
	Increase of exhaust resistance	•Turbocharger - Inspect (Refer to P8-20.) •Exhaust pipe - Check •Contact your MHIET dealer.
Engine body	Compression pressure drop	•Contact your MHIET dealer.
	Faulty valve timing	•Contact your MHIET dealer.
	Increase of sliding friction	•Contact your MHIET dealer.
Load system	Excessive load	•Load system - Check •Contact your MHIET dealer.
Rig	Excessive load	•Propeller matching - Adjust

Note: The table above also includes the parts that MHIET does not supply. For inspection and maintenance of the parts that are not supplied by MHIET, follow the instructions in the supplier's operation manual.

Excessive Fuel Consumption

Table 11-8 Excessive Fuel Consumption

Cause		Remedy
Fuel system	Fuel injection nozzle malfunction	•Contact your MHIET dealer.
	Faulty fuel injection timing	•Fuel injection pump drive coupling - Inspect •Contact your MHIET dealer.
	Improper fuel properties	•Use appropriate fuel. (Refer to P4-1.)
	Fuel leaks from fuel line or injection pipe	•Fuel lines and injection pipes - Check and Tighten •Contact your MHIET dealer.
Cooling system	Overcooling	•Control system - Inspect •Thermostat - Inspect •Contact your MHIET dealer.
Inlet and exhaust systems	Insufficient amount of intake air	•Turbocharger - Inspect (Refer to P8-20.) •Pre-cleaner - Clean, Inspect, and Replace (Refer to P8-21.) •Intake air pressure and intake air leaks - Inspect •Intake air temperature and ventilation system - Inspect •Contact your MHIET dealer.
	Increase of exhaust resistance	•Turbocharger - Inspect (Refer to P8-20.) •Exhaust pipe - Inspect •Contact your MHIET dealer.
Engine body	Compression pressure drop	•Contact your MHIET dealer.
	Faulty valve timing	•Contact your MHIET dealer.
	Rapid wear of sliding parts	•Contact your MHIET dealer.
Rig	Excessive load	•Propeller matching - Adjust

Note: The table above also includes the parts that MHIET does not supply. For inspection and maintenance of the parts that are not supplied by MHIET, follow the instructions in the supplier's operation manual.

Excessive Engine Oil Consumption

Table 11-9 Excessive Engine Oil Consumption

Cause		Remedy
Fuel system	Faulty fuel injection timing	•Fuel injection pump drive coupling - Check •Contact your MHIET dealer.
Lubricating system	Oil leakage to the outside of the engine	•Oil leaks - Check •Contact your MHIET dealer.
	Engine oil viscosity is low	•Use the oil having appropriate viscosity. (Refer to P5-4.)
	Excessive engine oil temperature	•Engine oil level - Check (Refer to P3-10.) •Oil cooler and oil thermostat - Check •Contact your MHIET dealer.
Cooling system	Overheating	•Control system - Check •Thermostat - Check •Contact your MHIET dealer.
Inlet and exhaust system	Oil intrusion into air supply chamber	•Contact your MHIET dealer.
	Friction of valve train parts	•Contact your MHIET dealer.
Engine body	Friction of sliding part	•Contact your MHIET dealer.
Load system	Excessive load	•Load system - Check •Contact your MHIET dealer.

Note: The table above also includes the parts that MHIET does not supply. For inspection and maintenance of the parts that are not supplied by MHIET, follow the instructions in the supplier's operation manual.

Overheating

Table 11-10 Overheating

Cause		Remedy
Cooling system	Insufficient coolant level	•Coolant leaks - Inspect •Coolant level - Check (Refer to P3-11.)
	Water pump faulty operation	•Contact your MHIET dealer.
	Thermostat malfunction	•Contact your MHIET dealer.
Load system	Excessive load	•Load system - Inspect •Contact your MHIET dealer.
Engine body	Rapid wear of sliding parts	•Contact your MHIET dealer.

Note: The table above also includes the parts that MHIET does not supply. For inspection and maintenance of the parts that are not supplied by MHIET, follow the instructions in the supplier's operation manual.

Engine Oil Pressure Drop

Table 11-11 Engine Oil Pressure Drop

Cause		Remedy
Lubrication system	Low engine oil level	•Engine oil level - Check (Refer to P3-10.)
	Faulty engine oil property (viscosity)	•Oil property analysis. Use appropriate engine oil. (Refer to P5-4.)
	Oil temperature too high	•Cooling system - Check •Contact your MHIET dealer.
	Clogged oil filter	•Oil filter and bypass oil filter - Inspect and replace (Refer to P8-10.)
	Faulty oil pump operation	•Contact your MHIET dealer.
	Faulty relief valve operation	•Contact your MHIET dealer.
Control system	Faulty pressure unit operation	•Control system and wiring - Inspect •Contact your MHIET dealer.
Engine body	Rapid wear of sliding parts	•Contact your MHIET dealer.
	Increased clearance of sliding part	•Contact your MHIET dealer.
Load system	Excessive load	•Load system - Inspect •Contact your MHIET dealer.

Note: The table above also includes the parts that MHIET does not supply. For inspection and maintenance of the parts that are not supplied by MHIET, follow the instructions in the supplier's operation manual.

When Fuel has Run Out

When the engine stops due to fuel runout while engine is running, restart the engine as described below:

1. Turn the starter switch to the "OFF" position.

2. Add fuel to the fuel tank.

For refilling fuel tank, refer to ["Fuel Tank Oil Level - Check" \(3-10\)](#).

3. Bleed air from the fuel system.

To bleed air from the fuel system, refer to ["Bleeding the Fuel System" \(3-1\)](#).

4. Start the engine.

For engine starting procedure, refer to ["Start-up" \(3-13\)](#).

Chapter 12 MAIN SPECIFICATION

Main Specifications

Table 12-1 Main specifications

Item	Specifications
Engine model	S6M3H-T2MTKL
Type	Vertical, water-cooled, 4-stroke cycle, turbocharged with intercooler
No. of cylinders - Arrangement	6 cylinders, in-line
Cylinder bore × stroke	108.9 × 135 mm [4.287 × 5.31 in.]
Displacement (declared value)	7.54 L [460.19 cu. in.]
Combustion type	Direct injection system
Compression ratio	14.6 : 1
Firing order	1 - 12 - 5 - 8 - 3 - 10 - 6 - 7 - 2 - 11 - 4 - 9
Rotation direction	Counterclockwise as viewed from flywheel side
Dimensions (L × W × H)	1888.5 × 1119 × 999 mm [74.350 × 44.06 × 39.33 in.] (with MGN123GX marine gear)
Dry weight	Approx. 1125 kg [2480 lb.] (with marine gear)
Fuel	Diesel fuel
Fuel injection pump	DENSO NB type
Fuel filter	Cartridge type paper-element
Fuel injection nozzle	Hole type
Initial fuel injection pressure	22.6 MPa (230 kgf/cm ²) [2378 psi]
Governor	Mechanical centrifugal type (all-speed control)
Lubricating method	Forced circulation (pressure feed by oil pump)
Lubrication oil	CF or CH-4 grade oil (API service classification)
Engine oil capacity	Approx. 43 L [11.4 U.S. gal.]
Oil filter	Cartridge type paper-element
Oil cooler	Water-cooled, multi-plate type
Cooling method	Seawater cooled multi-tubular method
Cooling water capacity	Approx. 32 L [8.5 U.S. gal.]
Starting method	Electrical start
Starter	DC24 V - 5 kW
Alternator	24 V - 35 A
Turbocharger	Mitsubishi TD08H
Marine gear	MGN123GX
Marine gear reduction ratio	1.97
Marine gear oil	Approx. 5.0 L [1.3 U.S. gal.]

Note: The specification above are subject to change without prior notice.

[illegible]

Mitsubishi Marine Engine S6M3H-T2MTKL OPERATION & MAINTENANCE MANUAL

Issued in March 2025

Pub. No. 298T1-40120 Revision:1

Issued by Mitsubishi Heavy Industries Engine & Turbocharger, Ltd.
3000, Tana, Chuo-ku, Sagamihara, Kanagawa, 252-5293, Japan

Edited by MHI Sagami High-tech LTD.

Printed and bound by Fuji Film Service Link Co., Ltd.

-
- The manual with incorrect collating or missing pages is to be replaced.
 - Without written approval from the publisher, for all or some part of this manual, unauthorized reproduction, copy, reprinting in any way or method are prohibited.



March 2025

OPERATION & MAINTENANCE MANUAL S6M3H-T2MTKL

Pub. No. 298T1-40120